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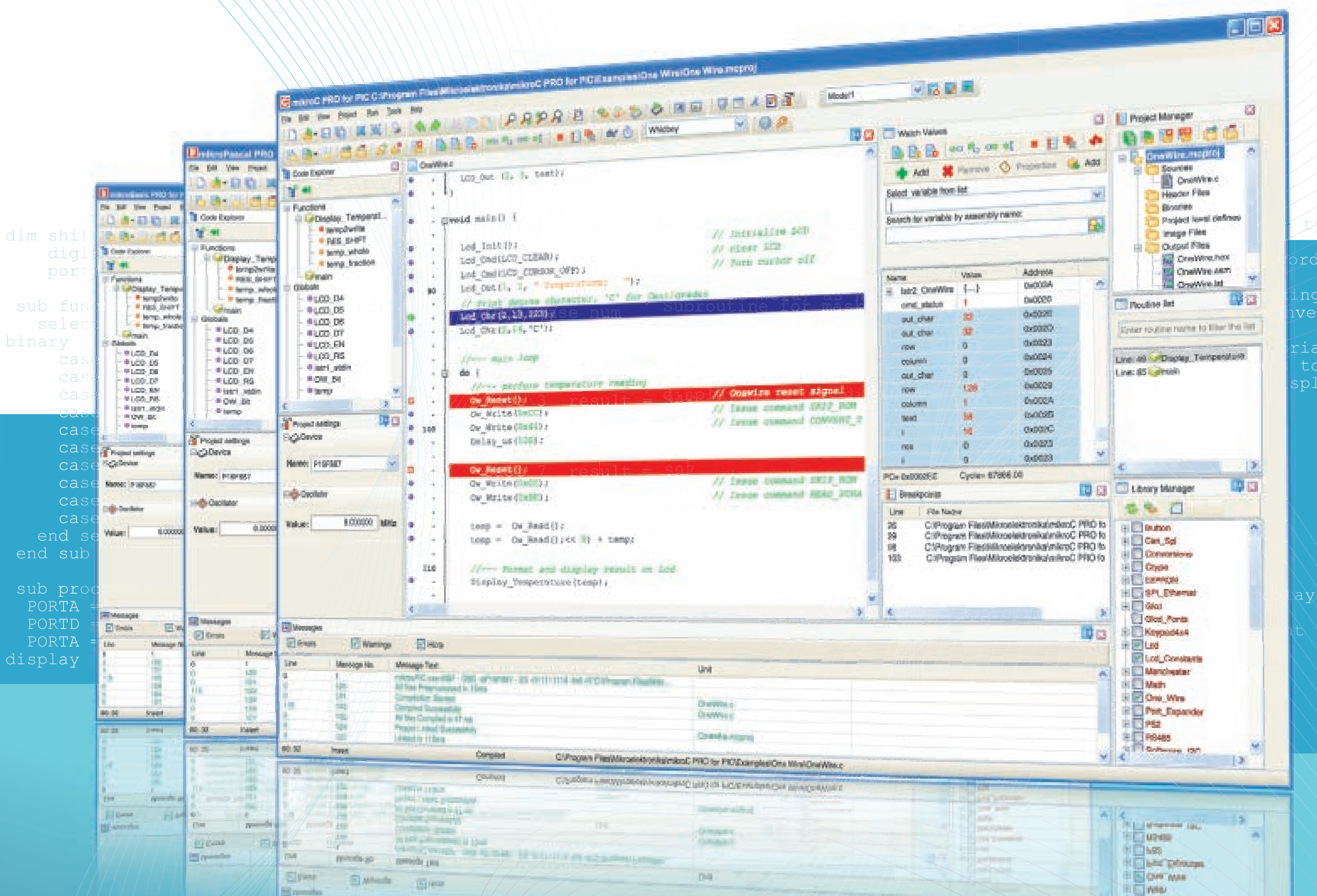

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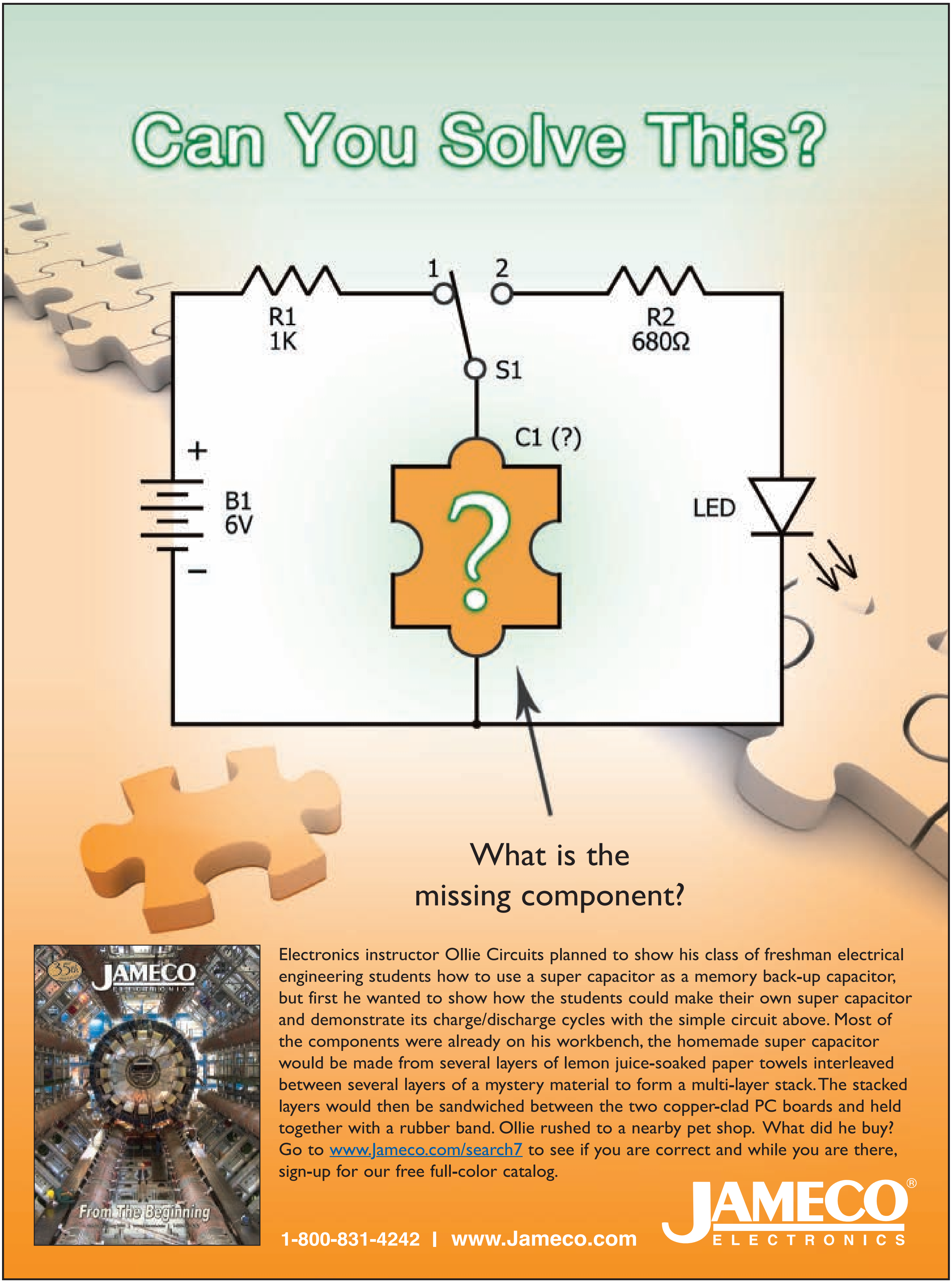
Can You Solve This?
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2
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680Ω
S1
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+
B1
6V
-
LED
?
What is the
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From The Beginning
Electronics instructor Ollie Circuits planned to show his class of freshman electrical engineering students how to use a super capacitor as a memory back-up capacitor, but first he wanted to show how the students could make their own super capacitor and demonstrate its charge/discharge cycles with the simple circuit above. Most of the components were already on his workbench, the homemade super capacitor would be made from several layers of lemon juice-soaked paper towels interleaved between several layers of a mystery material to form a multi-layer stack. The stacked layers would then be sandwiched between the two copper-clad PC boards and held together with a rubber band. Ollie rushed to a nearby pet shop. What did he buy? Go to www.Jameco.com/search7 to see if you are correct and while you are there, sign-up for our free full-color catalog.
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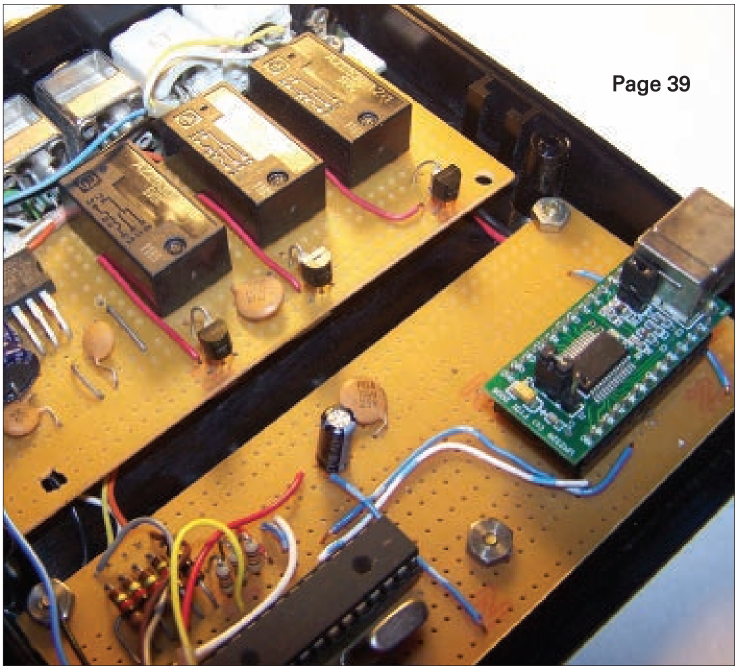

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FUNdamentals For Beginners

Just getting started in electronics? Try these simple demos to illustrate electronics principles and how components function in actual circuits!

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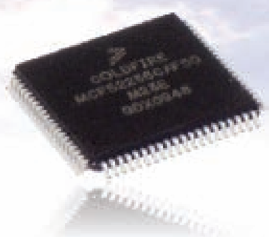

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DEVELOPING PERSPECTIVES

Designing For The Best-Case Scenario

On a recent business trip to the Middle East, I had the pleasure of spending a few nights in the desert with a camel herder. Base camp consisted of a makeshift trailer with an old generator a few dozen yards away for power and lights. In the quiet of the desert, the generator was piercing. We voted to go without the floodlights to enjoy the silence.

Given the abundance of sunlight, I asked why solar panels and batteries weren't used to power lights at night. I was lead to the roof of the trailer where the owner showed me three solar panels, each rated at 26V @ 4A. The US manufactured panels were apparently still functional, but collapsed for storage and without the matching batteries. The owner said the panels had destroyed two sets of 100 Ah deep-discharge batteries over the past few months, at considerable expense. The solar panels simply overcharged the batteries.

The designers of the solar power system apparently hadn't considered the best-case scenario of days filled with blue skies and intense, uninterrupted, sunlight for weeks on end. They were probably more concerned with performance on overcast days and, at best, a day or two per week of uninterrupted sunshine. This oversight in design got me thinking about electronic design in general.

How often do you design for the best-case scenario? I have to admit that I normally design for the typical scenario with an eye to the worst case. For example, in RF links, I don't assume the transmitter and receiver are in immediate proximity but may be at or just past maximum range. When it comes to switching power supplies, I'm constantly trying to squeeze the last bit of energy out of a battery before the supply shuts down.

Design for the best-case scenario is fundamentally different from over-engineering in which the goal is to produce a more robust circuit or system. Examples of over-engineering include using a transistor heatsink significantly larger than necessary to keep the junction temperature below maximum rated temperature, and building a power supply with diodes rated at four or five times the PIV expected.

Over-engineering requires knowledge of what's expected at the extremes of circuit operation, as well as deep pockets. The return is often increased reliability and enhanced performance.

Designing for the best-case scenario seems fundamentally different from and at odds with over-engineering. Take a wind generator. Designing for the worst-case scenario (as I see it) means designing the wind generator so that it requires virtually no wind. In contrast, a wind generator design that considers the best-case scenario would have provisions for operating in excessively high winds.

Do you intentionally over-design your circuits, or do you go for the cheapest solution that should work? Cost is an important, unavoidable consideration in today's economy, especially if you're building a circuit for educational purposes. There usually isn't much at stake if a resistor or transistor in one of your projects overheats and has to be replaced. That's how you develop an intuitive feel for what you can get away with in terms of power and voltage ratings.

The take-home message is to consider the best-case scenario when you're designing your next circuit. You don't want your circuit to fail because of too much of a good thing. **NV**

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READER FEEDBACK

TUBULAR THINKING

The April '10 issue with the "Shortwave Listening" article got a good start by Louis Frenzel remembering his S38B which was a very basic shortwave set. The article then proceeded to the purchase of modern-day sets available from present-day manufacturers. It needs mention that there are still lots of tube sets by Hallicrafters, National, and Hammarlund that are still useable. Look for general coverage with bandspreading tuning, BFO (beat frequency oscillator), and decent physical condition inside and out at a minimum. Additional features such as a crystal filter, Q-Multiplier, notch filter, bandpass tuning, and noise limiter are all good extras to the basic set. Be aware that some sets need an external speaker. If you get a set that has not been used for a long time, seek a radio shop or person who can help you check the set out first before and not after the "magic" smoke comes out as that can happen and be very discouraging. Then, you will have a genuine retro SWL "setup" as they used to say that glows in the dark while you pull in those exotic and distant stations!

Dennis R. Murphy K0GRM
Bismarck, ND

RESPONSE:

Thanks for your comments on my SWL article. You are right about there being tube radios out there. I was afraid to mention them given the problems that a person might have if they are not a good troubleshooter or electronics repair person. Finding tubes is one problem. Another is a bad filter and other capacitors that can kill a set. Replacing them is a pain. Otherwise, the tube sets still do a great job on SW and it is a cheap option for a good tinkerer.

We always appreciate the feedback.

73, Lou Frenzel W5LEF

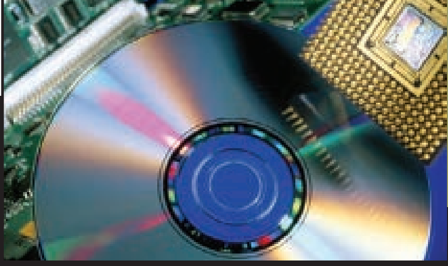
PROPS FOR ONLINE ACCESS

Just used the online "Texterity" system to access an article from Nov '05 — I had that issue, but the article was not one that I cut out for my binder. An excellent system! Got the information I was seeking printed out for the project folder.

I'll continue to support your magazine through the local Chapters store, and wish you continued success.

Thanks again.

Bruce Dingwall
Burlington, ON



TECH KNOWLEDGEY 2010

EVENTS, ADVANCES, AND NEWS

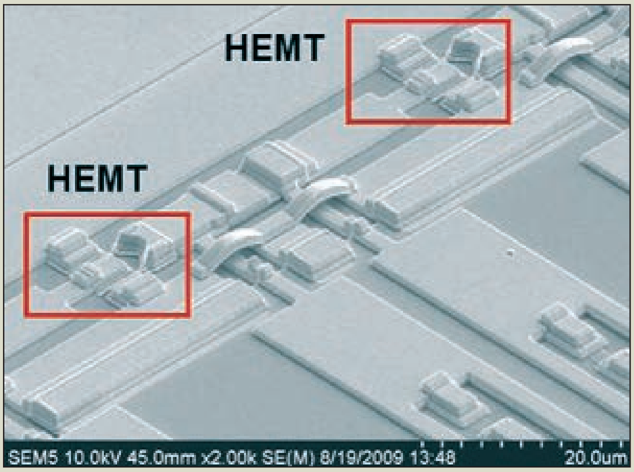
■ BY JEFF ECKERT

ADVANCED TECHNOLOGY

IC HITS 670 GHz

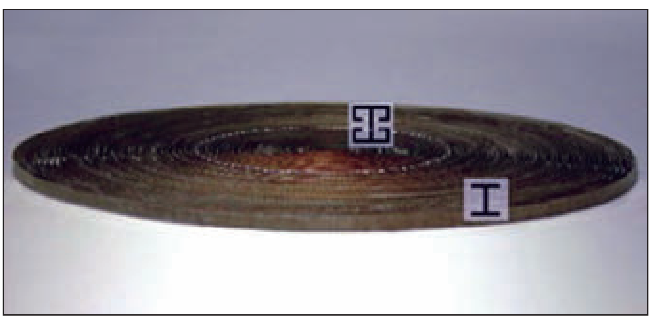
In what appears to be a new performance record for electronics, Northrop Grumman (**www.northropgrumman.com**) recently demonstrated its TeraHertz Monolithic Integrated Circuit (TMIC). Although with an operating speed of 0.67 THz, it doesn't quite live up to its name. The company did state that this more than doubles the frequency of the fastest reported integrated circuit. The name reflects that it was developed under a contract with DARPA's TeraHertz Electronics program which is aimed at developing high-power amplifier modules and teraHertz transistor electronics that operate at center frequencies exceeding 1.0 THz. The TMIC falls into the latter category.

At this point, it looks like the intended applications are strictly military, so don't expect to have one embedded in your stash of consumer electronics anytime soon. According to program manager William Deal, "A variety of applications exist at these frequencies. These devices could double the bandwidth — or information carrying capacity — for future military communications networks. TMIC amplifiers will enable more sensitive radar and produce sensors with highly improved resolution." Along the same lines, DARPA THz Electronics program manager John Albrecht noted, "The success of the THz Electronics program will lead to revolutionary applications such as THz imaging systems, sub-mm-wave ultra-wideband ultra-high-capacity communication links, and sub-mm-wave single-chip widely-tunable synthesizers for explosive detection spectroscopy." But at least we can watch in amazement. ▲



■ SEM showing details from a prototype 670 GHz integrated circuit utilizing 10 micrometer high electron mobility transistors.

CHINESE CREATE ARTIFICIAL BLACK HOLE



■ The omnidirectional electromagnetic absorber developed at China's Southeast University.

Details are sketchy and photos are blurry, but some scientists at the State Key Laboratory of Millimeter Waves at Southeast University in Nanjing, China (**www.seu.edu.cn**) have designed and fabricated what is somewhat exaggeratedly described as an "artificial black hole." Unlike a real black hole, it doesn't soak up matter but it is capable of absorbing microwave radiation. The device is a thin cylinder made up of 60 concentric rings of copper-coated metamaterials (i.e., a class of composites that can distort light and other waves). Each layer is imprinted with alternating patterns that allow it to trap and absorb electromagnetic waves coming from all directions by spiraling the radiation inward and converting it into heat. According to its developers, it provides an absorption rate of 99%. At present, it only works with microwaves, but the next step is to develop a device that sucks in visible light.

According to a paper published in the *New Journal of Physics*, "The good agreement between theoretical and experimental results has shown the excellent ability for metamaterials as the candidate to construct artificial omnidirectional absorbing devices. Since the lossy core can transfer electromagnetic energies into heat energies, we expect that the proposed device could find important applications in thermal emitting and electromagnetic-wave harvesting." Yeah, yeah. We all know he's thinking about cloaking devices. ▲

COMPUTERS AND NETWORKING

BOOKS FROM CANUCKS

The e-reader market is booming, with sales projected to reach 14 million units by 2013, according to research firm Informa Telecoms & Media (**www.informatm.com**). Unfortunately for vendors, Informa also sees a slide in sales after that, mostly as a result of losing market share to multifunctional devices. (The iPad, for example, had already grabbed 16% of the market as of last May.) It's also going to get tougher for high-end readers which are facing a growing herd of competitors. Reportedly, the number of e-reader vendors has grown from two in 2009 to more than 150 today. This can be good news, though, if you have been waiting for the prices to come down before buying one. A recent example is the Kobo Reader (**www.koboereader.com**), built in Toronto and available through Borders in the U.S.A. at $149 Canadian. The US dollar price had not been announced as of this writing, but with the currencies presently nearly at parity, there shouldn't be much difference. This undercuts the Sony PRS-300 Reader by $50 and both Amazon's Kindle and Barnes & Noble's nook by $110. Kobo's specs seem to be comparable, and it even comes with 100 free preloaded books and offers both USB and Bluetooth connectivity. So, if $150 sounds reasonable, now may be the time to take the plunge. (Personally, I'm holding out for $29.99.) ▲

■ The Kobo e-reader, built in Canada and sold by Borders.

YOUR OWN TELEPROMPTER

If you produce video blogs or other audio/visual public addresses, you'll probably want to know about TeleKast — a free program that allows you to write or import a script, edit it, and display your speech in large, bold, white type against a black background. When the script is ready, all you have to do is put a webcam on top of your monitor and act presidential.

TeleKast is presently in alpha test phase, so it may be a little buggy, and not all of its planned features are included. The price is right (free), however, so you just need to go to **sourceforge.net/projects/telekast/** and download it. The program is based on the Mozilla platform, so it relies heavily on Mozilla's XML User Interface Language and Javascript, and apparently it requires you to download XUL Runner from the Mozilla site (**www.mozilla.org**) to use it. Versions are currently available for both Windows and Linux; Mac OS is not supported because "we do not have a Mac for application testing." ▲

■ Seagate's Momentus XT hybrid drive — near-SSD performance at an HDD price.

SPEEDY LAPTOP STORAGE INTRODUCED

The concept of a hybrid (i.e., part mechanical, part Flash) drive isn't all that new and, in fact, Seagate (**www.seagate.com**) rolled one out a few years ago as an energy-saving tool for laptops. Now the company has introduced the Momentus XT with emphasis on its read/write performance as compared to standard HDs. What you get is a 2.5 inch, 7,200 rpm ATA drive combined with 4 GB of solid-state memory and 32 MB of DDR3 cache. The result, according to Seagate, is a storage system that is nearly as fast as Flash at a much lower price. Memory allocation is handled by the company's "adaptive memory technology" which basically identifies your most frequently used data and sticks it into the solid-state area so it's always ready when you need it.

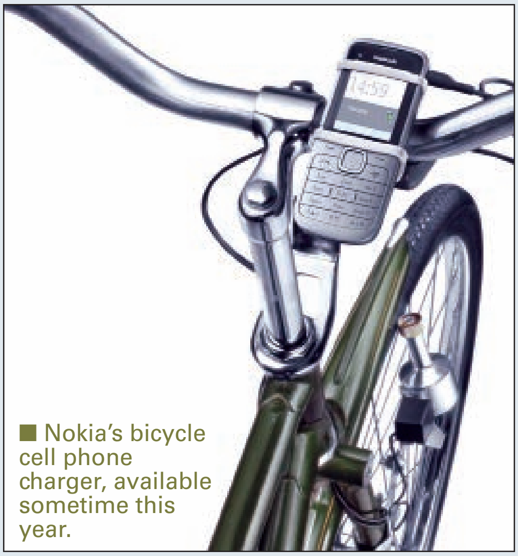
According to Seagate's marketing guy Dave Mosley, "We see the drive as a game changer, a product heralding a new generation of hard drives that combine SSD and HDD capabilities so that laptop users don't have to make trade-offs on speed, cost, or capacity."

Three models are currently available offering 250, 320, or 500 GB capacity, with list prices of $113, $122, and $156, respectively. ▲

CIRCUITS AND DEVICES

TALK WITH PEDAL POWER

When your cell phone batteries get low, you generally have only two options: charge it from an AC outlet or from the cigarette lighter jack in your car. Coming soon from Nokia (**www.nokia.com**) is a bicycle charging kit that will allow you to tap into pedal power to keep the conversation going. The kit consists of the charging unit and a small generator (driven by the turning wheel), plus a handlebar mounting bracket for the phone itself. If your prime interest is saving the Earth, using the device won't accomplish a lot. The generator is rated at 3W which doesn't amount to much either in fossil fuel or cost. In mechanical terms, that translates into draining less than 0.005 horsepower from your leg muscles which shouldn't be too much of a strain. If you like to take long rides in the country or live in an area where cars and electricity are scarce (the device was originally introduced in Kenya), this could be a nifty little solution. According to Nokia, the charger is compatible with any of its phones that use the standard 2 mm charging jack. ▲



■ Nokia's bicycle cell phone charger, available sometime this year.

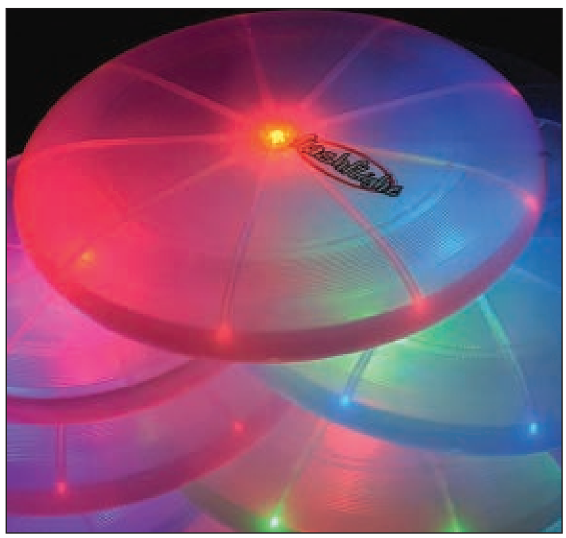
MAKING THE SD-TO-USB CONNECTION

■ The Mobidapter SD-to-USB connector from Saelig.

One of the most common ways to store and transfer data is via a USB memory stick, but the devices are not compatible with cell phones and PDAs —or at least they weren't until Saelig Co. (**www.saelig.com**) introduced the Mobidapter. This is a USB memory stick reader that plugs directly into the SD memory slot on your portable device, allowing you to transfer photos, MP3 files, word processor files, and pretty much anything else to or from it. Power is provided from the host device, so no batteries are needed and Mobidapter works with virtually any mobile device that has an external SD socket. Plus, because it requires no drivers, it is compatible with any operating system. The $39.95 price tag seems a little steep for a relatively simple connector, but if you need it, you need it. ▲

THE NIGHTTIME IS THE RIGHT TIME

Sure, it's just another toy, but admit it — you want one. The Flashflight flying disc (Frisbee being someone else's registered trademark) from Nite Ize (**www.niteize.com)** was designed by a professional Ultimate player to allow you to keep on playing even after the sun goes down. According to the company, the 185 gram flyer looks, feels, and flies like the highest quality non-illuminated discs, so you can use it by day, as well. Push a button, and you switch on an LED/fiber optic array that extends from the center to the rim so you can see it from every angle. They say it is "for everyone from the serious athlete to your crazy Uncle Max," and it even floats, so you can use it in the pool. The flyers are available in a choice of four colors, and custom printing (e.g., your company logo) is available. It even comes with a pair of replaceable lithium coin cells. The Flashflight lists for $24.99, but you can find them in Internet stores for as little as $13. Just try not to trip over the line trimmer that you forgot to put away. ▲



■ The Flashflight flying disc from Nite Ize.

INDUSTRY AND THE PROFESSION

GOOGLE TV GETS CLOSER

Not everyone is eager to move the WWW from the PC to the living room, but Google and quite a few industry leaders are bringing it to us anyway. Late in May at the Google I/O developer conference, a slew of companies joined ranks to support Google TV — an open platform that aims to merge the Internet with television viewing. This will usher in a new category of hardware designed to handle it, beginning with the Sony Internet TV which will be the first receiver lineup to incorporate Google TV. Other partners who have jumped in so far include Intel, Logitech, Best Buy, DISH Network, and Adobe. Google TV is based on Sprint's Android platform and runs the Google Chrome browser. Users can access their usual TV channels plus a range of Internet and cloud-based information and apps — including Adobe® Flash-based content — without getting up off the couch. They can also get streaming video from the likes of Netflix, Amazon Video On Demand, and YouTube.

If you're interested in joining in the fun as a developer, now is the time. Google has announced an upcoming release of a set of TV-specific APIs for web applications, encouraging developers to begin building unique web applications for use on the television sets. Later this year, Google will also release an updated Android SDK which will support applications built for Google TV. ▲

APPLE FINALLY TOPS MICROSOFT

In case you didn't notice the event, Apple guy Steve Jobs finally turned the table on rival Bill Gates. As of May 26, Apple's market capitalization (total value of its stock) stood at $223 billion, with Microsoft running second at a paltry $219.3 billion. On that particular day, a share of Apple cost $244.13 — up 86% from a year before. Now don't you wish you had bought yourself a few thousand shares back in 1997 when it bottomed out at $12.94? **NV**

PICAXE PRIMER

SHARPENING YOUR TOOLS OF CREATIVITY

■ BY RON HACKETT

INTRODUCING TEX AND REX: THE IR TWINS

If you're a regular reader of the PICAXE Primer, you may remember our three-part exploration of the IR Multi-Board (Oct and Dec '08, and Feb '09) which we used to implement the entire range of PICAXE IR functions. In this month's column, we're going to re-visit the infrared realm, but this time we're going to take a different approach and develop two very simple IR boards — each of which serves only one specific function. Rex will be our IR receiver and Tex will transmit IR signals to Rex. As usual, there are two different versions of each of these boards (see Figure 1). We're going to construct the stripboard versions here, but if you prefer, the PCB versions are available on my website. For both Tex and Rex, the stripboard and PCB versions are functionally the same. The only differences are in the order and selection of the six pins on the connecting headers.

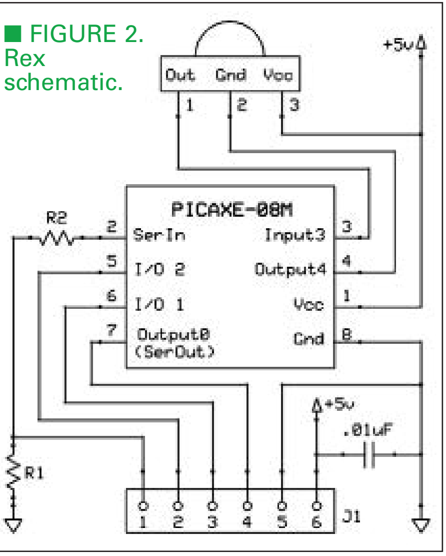
CONSTRUCTING AND TESTING REX

Let's begin with Rex. **Figure 2** presents his schematic and **Figure 3** contains the list of required parts. As you can see, Rex is very simple; the circuit essentially consists of an 08M processor and a PNA4602 IR detector. Two of Rex's spare I/O pins (1 and 2) are brought out to a six-pin header that can be easily inserted into a breadboard. The basic PICAXE programming circuit is included in case you are using a serial programming connection. (If you are using a USB adapter, program downloading will still function correctly.)

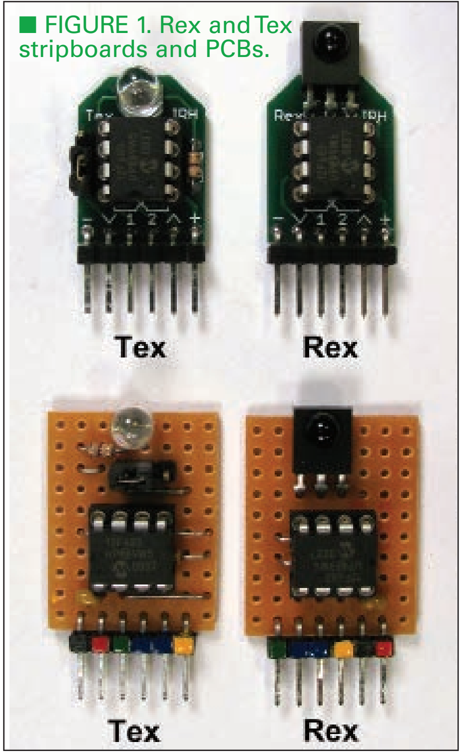
The only unusual feature of the circuit is that pin 2 (ground) of the PNA4602 is connected to the 08M's output4. As we'll soon see, this arrangement simplifies the stripboard circuit. However, it also means that in order for Rex to function correctly, any program we develop for him must include a "low 4" statement so that the 4602 is properly grounded. If you forget to include it (like I did in my very first testing of Rex), your program won't work at all!

Figure 4 presents the top and bottom views of the layout for Rex's stripboard circuit. As you can see, the stripboard could actually be smaller than I made it because columns A and H are not used at all. I included them to make the Rex and Tex boards the same size, but if you prefer a smaller board you certainly can omit them. In the layout, I used two four-pin female headers as the socket for the 08M so that the placement of the two resistors is clearly visible. (The "1" at the right side of the top header indicates pin 1 of the IC.)

■ FIGURE 2. Rex schematic.

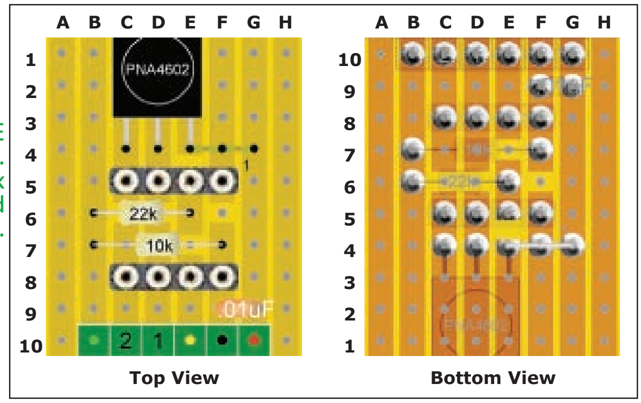


■ FIGURE 1. Rex and Tex stripboards and PCBs.



■ FIGURE 3. Rex Parts List.

Label	Part
-	Stripboard (8 Traces of 10 Holes)
R1	Resistor, 10k, 1/6W
R2	Resistor, 22k, 1/6W
J1	Header, Male, Rt Angle, Six-pin
C1	Capacitor, .01µF
-	IC Socket, Eight-pin
-	PICAXE-08M
-	PNA4602 IR Detector



■ FIGURE 4. Rex stripboard layout.

When I actually constructed the circuit, I used an eight-pin machined-pin socket, but female headers would also work. Finally, if you look at the placement of the 4602, you can see why I chose to connect its ground pin (pin 2) to output4 of the 08M; doing so eliminated the need for two additional jumpers. Rex is very easy to construct, so I'm not going to go into detail on this. As usual, just work from the smallest to the largest parts. **Figure 5** is a close-up of the completed stripboard circuit for reference as you construct it. As you can see, I color-coded the header pins to remind myself of their functions.

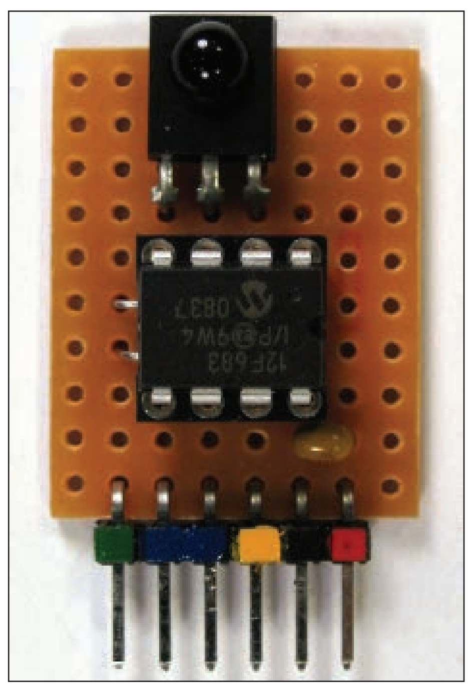
When you are ready to install the IC socket on top of the resistors, you may find that one of the resistors interferes with fully inserting the socket into the stripboard. If so, you can use a sharp hobby knife to shave off a little plastic as necessary from the socket. Before you solder the IC socket in place, be sure to orient it so that pin 1 is inserted into hole F5. Also, when you install the PNA4602, bend the lead on the bottom of the board from hole E4, snip it so that it reaches hole G4, and solder it at holes E4, F4, and G4. To test Rex, set up a circuit similar to the one shown in **Figure 6**. In the photo, I'm using an AxMate-FT adapter to connect to my Mac; your regular programming adapter will work just as well. Download the *RexTest.bas* program from the *N&V* website (**www.nutsvolts.com**) and use the Programming Editor to install it on Rex's 08M processor. Whenever you press a button on an SIRC TV remote control, its *infrain2* data value should appear in the terminal window. If not, you will need to re-check the wiring on your Rex board. In order to debug your setup, you may also want to connect an LED to Rex's output1 pin and add some code to the program to blink it each time Rex receives an IR transmission.

CONSTRUCTING AND TESTING TEX

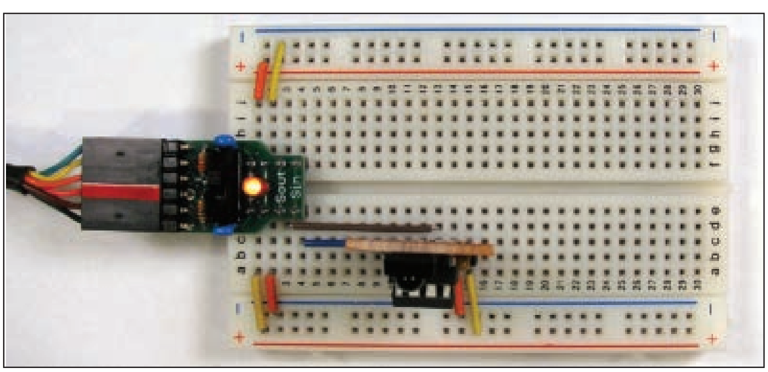
Tex is almost as simple as Rex. **Figure 7** presents his schematic and **Figure 8** is the parts list. (In order to maximize Rex's range, I chose 180Ω for resistor R3 because the resulting 22 mA current draw is close to the 08M's maximum output current of 25 mA.) Tex has only one purpose in life: to transmit IR signals to Rex or any other PICAXE-based project. Similarly to Rex, two of Tex's spare I/O pins (3 and 4 on the stripboard version, or 1 and 2 on the PC board) are brought out to the six-pin header so they are available for any breadboard project.

Tex is capable of transmitting two different types of IR signals which can be selected via the three-pin male header (J2) shown in the **schematic**. To transmit standard *infrain2* codes, a shorting jumper can be used to connect output0 to the IR-LED. To do so, you would install the jumper on the two pins on the right of J2 in the **schematic**. (In the actual stripboard layout, it's the two pins on the left of the three-pin header.)

That's the way we will be using Tex here, but you may want to experiment with the second type of IR signal. If you move the shorting jumper to the other end of the three-pin header, the IR-LED is connected



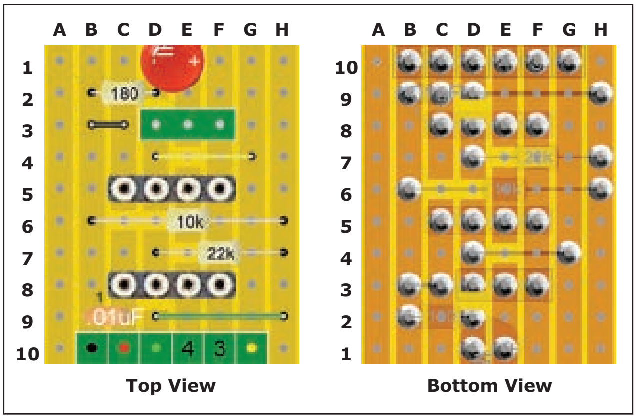
■ FIGURE 5. Completed Rex stripboard.



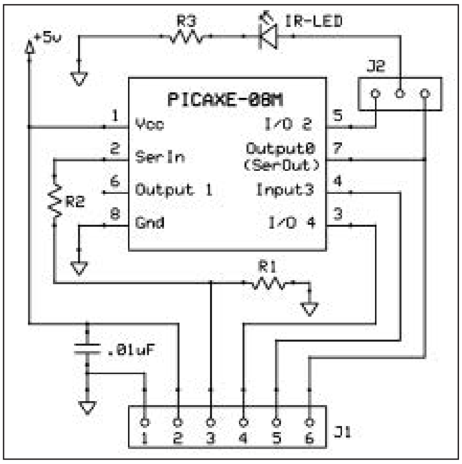
■ FIGURE 6. Rex test setup.

■ FIGURE 8. Tex Parts List.

Label	Part
-	Stripboard (8 Traces of 10 Holes)
R1	Resistor, 10k, 1/6W
R2	Resistor, 22k, 1/6W
R3	Resistor, 180 , 1/6W
J1	Header, Male, Rt Angle, Six-pin
C1	Capacitor, .01 F
-	IC Socket, Eight-pin
-	PICAXE-08M
-	Header, Male, Straight, Three-pin
-	IR-LED



■ FIGURE 9. Tex stripboard layout.



■ FIGURE 7. Tex schematic.

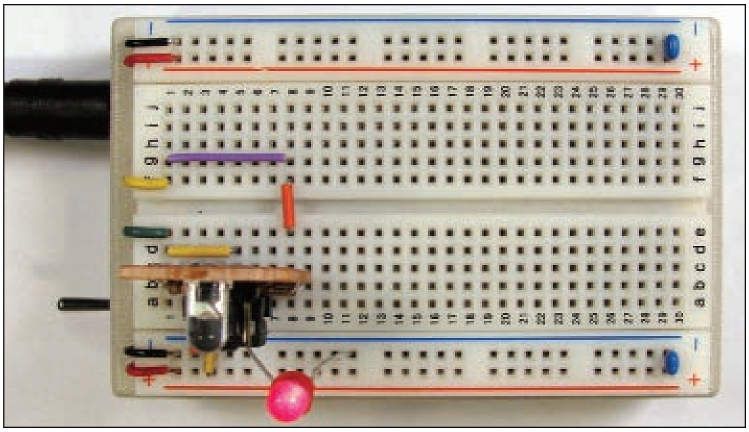
to output2 of the 08M which is capable of outputting PWM signals. As you know, the PNA4602 is capable of receiving IR signals that are modulated on a 38 kHz carrier wave, so a 38 kHz PWM signal can be used to generate an IR "beam" to detect objects in its path.

For example, an IR beam-generating Tex could be placed on one side of a hallway with Rex on the other side. This combination would be able to detect any person or other object that crosses the IR beam.

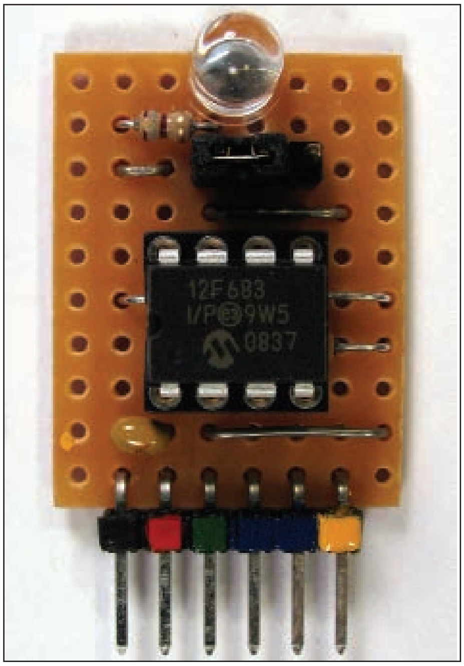
Figure 9 shows the top and bottom views of the layout for Tex's stripboard circuit. In the layout, I have again used two four-pin female headers as the socket for the 08M so that the placement of the two resistors is clearly visible. Note that the orientation of Tex's 08M processor is reversed from that of Rex (i.e., for Tex, pin 1 of the 08M is at the left end of the lower female header). As before, you can use either an eight-pin machined-pin socket or the female headers for the 08M. Also note that, although the IR-LED is shown in the layout as pointing forward from the board, you could just as easily install it by first bending its leads 90 degrees so that it points directly up. This arrangement would be suitable for a hand-held IR transmitter. Tex is also very easy to construct, so just take a look at **Figure 10** for a close-up of the completed Tex stripboard for reference. When you are ready to install the IC socket on top of the resistors, you may again find that one of the resistors interferes with fully inserting the socket into the stripboard. If so, shave off a little plastic as mentioned previously. Before soldering the IC socket in place, be sure to orient it so that pin 1 is inserted into hole C8.

To test Tex, you may want to install the stripboard on a battery-powered breadboard so you can easily determine the effective transmission range. **Figure 11** is a photo of the setup that I used for this purpose. Either a regulated 5V supply or a 4.5V three-cell alkaline battery pack can be used. The battery-powered breadboard in the **photo** has the PICAXE programming circuit built into the same case that holds the battery; again, you can use any programming adapter you may have available.

For the initial testing of Tex, I included a debugging LED on output4. When you have assembled



■ FIGURE 11. Tex test setup.



■ FIGURE 10. Completed Tex stripboard.

the circuit, download the *TexTest.bas* program from the *N&V* website and use the Programming Editor to install it on Tex's 08M processor. Tex will repetitively transmit the digits 0 through 9 at the rate of one digit per second, and blink the debugging LED to indicate each transmission. To test Tex, use the same Rex setup as before (you may need to manually open the terminal window) and point Tex at Rex. You should see the digits 0 through 9 being displayed repetitively in the terminal window. (If not, you will need to re-check the wiring on your Tex board.) If you use a battery-powered breadboard for Tex, you may also want to determine the range of the system. My Rex-Tex system was able to communicate reliably at a distance of up to 15 feet.

USING TEX AND REX AS A WIRELESS LINK FROM A PIR MOTION SENSOR

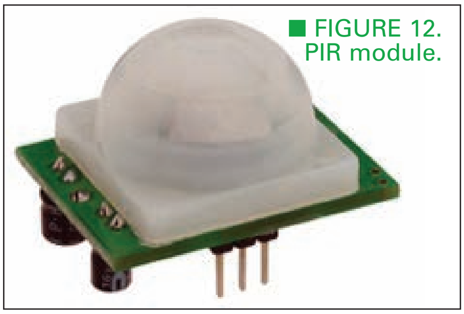
To demonstrate Tex and Rex in action, we're going to use them to establish a wireless communication link from a passive infrared (PIR) motion sensor. For this purpose, I'll use the PIR module shown in **Figure 12**. I purchased it at a local RadioShack (#276-033), but it's actually a Parallax module (#555-28027) so it's also available at **www.parallax.com** if you prefer. (The datasheet for the module can be downloaded from either the RadioShack or Parallax website.)

The module has a simple three-pin interface: Vcc (3.3 to 5V); Ground (0V); and a digital output that is normally low and goes high whenever motion is detected. The output isn't powerful enough to drive an LED (you could use a simple transistor driver circuit for that purpose), but it can be directly connected to any PICAXE input pin.

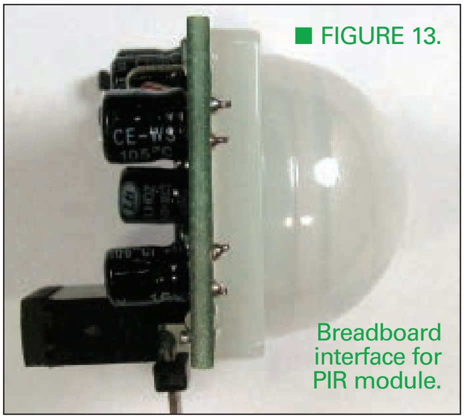
The PIR module includes an on-board jumper that determines the behavior of the output pin. When the jumper is in its "High" position, the output remains high when motion is repeatedly detected and times out after a few seconds of no motion; in the "Low" position, continuous motion results in a series of high/low pulses on the output pin. For our project, I decided to use the first option because it results in fewer data transmissions and therefore less power consumption. You may want to experiment with both output options. Unfortunately, the pins of the PIR module's three-pin interface point directly out from the back of its PCB, and other components mounted on the back of the board make it impossible to insert the module into a breadboard (see **Figure 12**). Parallax sells a three-wire cable to connect the module to a project, but I wanted to be able to directly insert it into my battery-powered breadboard. So, I made a simple adapter from two headers: a 5x2 straight female header and a five-pin straight male header (0.23" and 0.32" mating lengths).

First, I cut a piece of stripboard (five traces of two holes each) and soldered it to all 10 pins on the back of the female header. Next, I snapped a three-pin piece from the male header and bent the longer ends of the pins to a right angle. Finally, I inserted the male header into the middle of one row of the female header and then inserted the pins of the PIR module into the middle of the other row of the female header. Using this arrangement, the PIR module can be directly inserted into a breadboard (see **Figure 13**).

To implement the transmitting end of the wireless data link, I installed the PIR module on the same battery-powered breadboard that I used earlier to test Tex, and connected the output of the PIR module directly to input3 on Tex's six-pin header. The resulting setup is

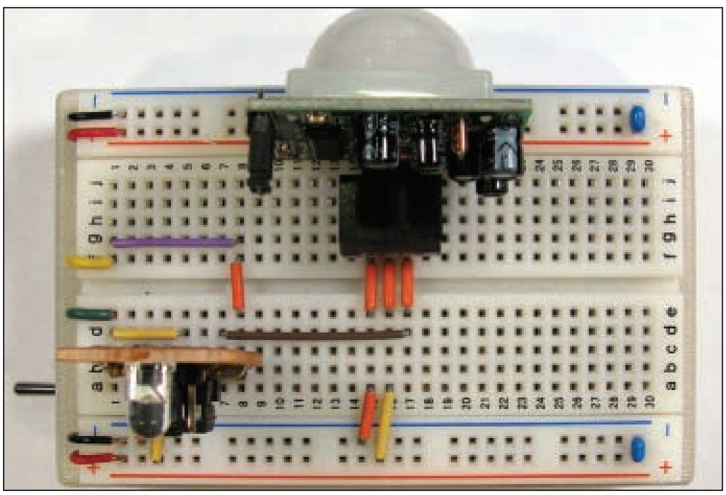


■ FIGURE 12. PIR module.



■ FIGURE 13.

Breadboard interface for PIR module.



■ FIGURE 14. PIR module and Tex on battery powered breadboard.

Resonator Speed	OSCCON Value
31kHz	%00000000
125kHz	%00010000
250kHz	%00100000
500kHz	%00110000
1MHz	%01000000
2MHz	%01010000
4MHz	%01100000
8MHz	%01110000

■ FIGURE 15. OSCCON values for various 08M resonator frequencies.

shown in **Figure 14**. For the receiving end of the link, I used the same setup that we used earlier to test the completed Rex board. The transmitting software for Tex (*TexOut.bas*) and the receiving software for Rex (*RexIn.bas*) is available on the *N&V* website. The programs are both very basic. Essentially, Tex repetitively checks input3 and transmits two different infrain2 codes: "0" = "no motion" and "1" = motion. Rex receives each transmission and relays an appropriate message to the terminal window. Download both programs, install each one on the corresponding board, and test your system.

DECREASING POWER CONSUMPTION IN BATTERY-POWERED PROJECTS

Because Tex is battery powered, it's a good idea to reduce power consumption as much as possible. There are three aspects of Tex's software that are helpful in this regard. First, the 08M has a feature called *brownout detection* (BOD) which cleanly resets the processor in the event of a power brownout (i.e., a temporary drop in the input voltage). It's a great feature for line-powered circuits but not really necessary with battery-based systems, and it does require a fair amount of power to operate. Fortunately, the 08M supports software commands to enable or disable BOD (*enablebod* and *disablebod*), so the inclusion of the *disablebod* statement in Tex's software reduces the power consumption of the circuit.

Second, because the IR-LED requires a fair amount of power, Tex only transmits a code when the state of input3 changes. That way, for long intervals (possibly hours at a time) there are no IR transmissions and a considerable amount of power is conserved. Finally, Tex takes a little 288 mS nap to slow down the speed of the main loop which further reduces his power consumption.

Back in the August '08 Primer, we explored the relationship between processor speed and power consumption with the 28X1 processor. The general rule is that slower processor speeds consume less power, so the 28X1's ability to operate at speeds as low as 31 kHz can be extremely important in battery-powered systems. If you look at the PICAXE documentation for the *setfreq* command, you will see that the only speeds available to the 08M are 4 MHz and 8 MHz.

However, the situation isn't quite that simple; the 08M is based on the Microchip PIC12F683 processor, and all PIC processors contain many "special function" registers that control various aspects of the processor's functioning. One of these registers (OSCCON, at hexadecimal location 8F) controls the 08M's internal resonator speed, so it's possible to use the *poke* command to change the value in the OSCCON register and

thereby change the operating speed of the 08M processor. In fact, the 08M can run at any one of the speeds available to the 28X1 via its *setfreq* command.

Figure 15 lists the values to place in the OSCCON register for each of the 08M's possible operating speeds. However, before you start experimenting, it's important to know that this is not something to be undertaken lightly. Accidentally "poking" the wrong value and/or the wrong special function register can have unexpected results — including crashing your program. Also, even when the 08M's operating speed is changed correctly, it may no longer respond to your trying to download an updated program. If that happens, powering down the 08M circuit, initiating a new download, and then re-powering the circuit should enable the download to proceed normally.

It's also important to remember that most of the 08M's time-sensitive commands will operate proportionally slower at lower resonator speeds. For example, at 4 MHz, a *pause 500* statement will (of course) take 500 mS to complete; at 31 kHz the same statement will take more than one minute to complete! Finally, some commands will not work at all; for example, the *infraout* command only functions at 4 MHz. So, if you want to slow Tex down as an additional power-saving tactic, you will first need to issue a *setfreq m4* statement (or poke the OSCCON register appropriately), then issue the command, and then re-poke the OSCCON register to return to the slower speed. I wrote a simple program that does exactly that; if you're interested in experimenting with it, you can also download from the *N&V* website.

Whether all this is worth it depends on how long you need your battery supply to last. To get a rough idea of the differences involved, I set up a simple 08M circuit with no power-consuming outputs, downloaded a program that consisted of a single, empty infinite do-loop, and measured the 08M's current-consumption. At 4 MHz with BOD enabled, it was approximately 840 µA; at 31 kHz with BOD disabled, that figure dropped to 135 µA — a savings of about 700 µA or 0.7 mA.

In order to understand how significant that difference may be, I also measured the current draw of the PIR module. When I moved in front of it, the module drew about 140 µA; with no motion, the current draw dropped to about 120 µA. Of course, the total current draw of the 08M and the PIR module together is much smaller than the 22 mA required to drive the IR-LED, but that happens only a very small percent of the time. I suspect that the 08M current-saving tactics may significantly increase battery life. In order to find out for sure, I intend to do some long-term testing — I'll keep you posted when the results are in.

Okay, that's it for this month. In the meantime, if you do your own testing of a battery-powered 08M project, I would be very interested in learning about your results. **NV**

It's Dog Day Kit Month!

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Digital Controlled FM Stereo Transmitters

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For nearly a decade we've been the leader in hobbyist FM radio transmitters. We told our engineers we wanted a new technology transmitter that would provide FM100 series quality without the advanced mixer features. They took it as a challenge and designed not one, but TWO transmitters!

The FM30 is designed using through-hole technology and components and is available only as a do-it-yourself kit with a 25mW output very similar to our FM25 series. Then the engineers redesigned their brand-new design using surface mount technology (SMT) for a very special factory assembled and tested FM35WT version with 1W output for our export only market!

All settings can be changed without taking the cover off! Enter the setup mode from the front panel and step through the menu to make all of your adjustments. A two line LCD display shows you all the settings! In addition to the LCD display, a front panel LED indicates PLL lock so you know you are transmitting.

Besides frequency selection, front panel control and display gives you 256 steps of audio volume (left and right combined) as well as RF output power. A separate balance setting compensates for left/right differences in audio level. In addition to settings, the LCD display shows you "Quality of Signal" to help you set your levels for optimum sound quality. And of course, all settings are stored in non-volatile memory for future use!

Both the FM30 and FM35WT operate on 13.8 to 16VDC and include a 15VDC plug-in power supply. The stylish black metal case measures 5.55"W x 6.45"D x 1.5"H. *(Note: After assembly of this do-it-yourself hobby kit, the user is responsible for complying with all FCC rules & regulations within the US, or any regulations of their respective governing body. FM35BWT is for export use and can only be shipped to locations outside the continental US or valid APO/FPO addresses or valid customs brokers for end delivery outside the continental US.)*

FM30B **Digital FM Stereo Transmitter Kit, 0-25mW, Black** **$199.95**
FM35BWT **Digital FM Stereo Transmitter, Assembled, 0-1W, Black (Export ONLY)** **$299.95**

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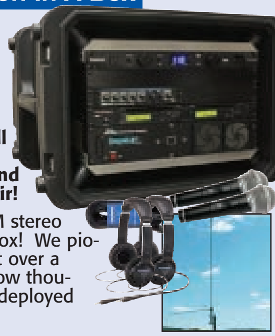
50W FM Station-In-A-Box



- ✔ 50w RF output!
- ✔ Dual program source decks!
- ✔ Laptop input!
- ✔ USB input!
- ✔ Dual mics, antenna, and all accessories!
- ✔ Just plug it in and you're on-the-air!

YES, a complete FM stereo radio station in-a-box! We pioneered the concept over a decade ago, and now thousands of them are deployed around the world!

The concept? It's simple. Whether your application is for disaster preparedness, military, educational, LPFM, or standard FM backup, wherever you may need to get on-the-air quick, without any hassles, the Ramsey PXB series is your immediate solution... Setup the antenna, plug it in, and you're on-the-air!

This 50W version is based on our proven and ultra reliable FCC Certified PX50 FM stereo transmitter designed for simple operation via the front panel navigation switch matrix. All controls and status messages are displayed on the 2 line by 20 character vacuum fluorescent display. Automatic protection circuits are designed to keep you on the air, rather than off. To compliment the transmitter we include our 3.4dB gain omnidirectional FM broadcast antenna and 100' of low loss LMR400 feed line with pre-assembled & tested connectors.

From there we give you 2 separate CD-MP3-SD-USB media players as well as an external (laptop, etc) input, all prewired into a professional 5 channel stereo mixer. 2 dynamic handheld microphones, XLR cables, clips, and desk stands are included for local origination. We top it all off with two sets of professional stereo monitor headphones.

The entire unit is factory assembled in a small 6 rack unit mil-spec shock case, and burned in at full power for 12 hours. Over 15 different models are available, with power ratings from 50 watts to 1,000 watts. Visit www.ramseyfm.com for details.

PXB5006D93S **FM Radio Station** **$5195.00**

Pocket Audio Generator

A perfect test source for stereo line inputs on any amplifier or mixer. Provides 50Hz, 100Hz, 1kHz, 10kHz, & 20kHz tones, plus 32 bit digital pink noise. Great to help you identify cables or left/right reversals! Stereo RCA line level outputs. Uses 2xCR2025, not included.

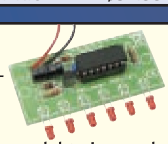
K8065 **Pocket Audio Generator Kit** **$32.95**

Pocket Vu Meter

Hand held audio level meter that fits in your pocket! Built-in mic picks up music and audio and displays it on an LED bargraph. Includes enclosure shown. Runs on one 3V Li-Ion button cell, not included. If you ever wanted an easy way to measure audio levels, this is it!

MK146 **Pocket Vu Meter Kit** **$8.95**

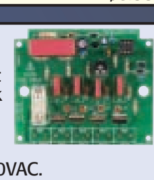
Mini LED Light Chaser



This little kit flashes six high intensity LEDs sequentially in order. Just like the K80302 to the right does with incandescent lights. Makes a great mini attention getter for signs, model trains, and even RC cars. Runs on a standard 9V battery.

MK173 **Mini LED Light Chaser Kit** **$15.95**

Running Light Controller



Controls and powers 4 incandescent lights so they appear to "travel" back and forth (Like the hood on KITT!). Great for the dance floor or promotional material attention getters, exhibits, or shows. Runs on 112-240VAC.

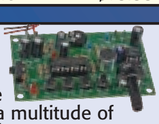
K8032 **4-Channel Running Light Kit** **$38.95**

High Power LED Driver

High power LED's have finally found their way into the hobbyist budget, but now you need a driver! This little board provides the accurate and constant current need to drive them. Delivers 350mA or 700mA at a constant current

K8071 **High Power LED Driver Kit** **$14.95**

Digital Voice Changer



This voice changer kit is a riot! Just like the expensive units you hear the DJ's use, it changes your voice with a multitude of effects! You can sound just like a robot, you can even ad vibrato to your voice! 1.5W speaker output plus a line level output! Runs on a standard 9V battery.

MK171 **Voice Changer Kit** **$14.95**

Steam Engine & Whistle

Simulates the sound of a vintage steam engine locomotive and whistle! Also provides variable "engine speed" as well as volume, and at the touch of a button the steam whistle blows! Includes speaker. Runs on a standard 9V battery.

MK134 **Steam Engine & Whistle Kit** **$11.95**

Electronic Watch Dog

A barking dog on a PC board! And you don't have to feed it! Generates 2 different selectable barking dog sounds. Plus a built-in mic senses noise and can be set to bark when it hears it! Adjustable sensitivity! Unlike the Saint, eats 2-8VAC or 9-12VDC, it's not fussy!

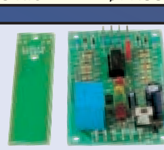
K2655 **Electronic Watch Dog Kit** **$39.95**

Laser Trip Senser Alarm

True laser protects over 500 yards! At last within the reach of the hobbyist, this neat kit uses a standard laser pointer (included) to provide both audible and visual alert of a broken path. 5A relay makes it simple to interface! Breakaway board to separate sections.

LTS1 **Laser Trip Sensor Alarm Kit** **$29.95**

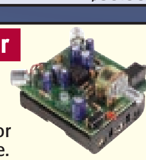
Liquid Level Controller



Not just an alarm, but gives you a LED display of low, middle, or high levels! You can also set it to sound an alarm at the high or low condition. Provides a 2A 240VAC rated relay output. Runs on 12-14VAC or 16-18VDC.

K2639 **Liquid Level Controller Kit** **$23.95**

Stereo Ear Super Amplifier



Ultra high gain amp boosts audio 50 times and it does it in stereo with its dual directional stereo microphones! Just plug in your standard earphone or headset and point towards the source. Incredible gain and perfect stereo separation!

MK136 **Stereo Ear Amp Kit** **$9.95**

Electret Condenser Mic

This extremely sensitive 3/8" mic has a built-in FET preamplifier! It's a great replacement mic, or a perfect answer to add a mic to your project. Powered by 3-15VDC, and we even include coupling cap and a current limiting resistor! Extremely popular!

MC1 **Mini Electret Condenser Mic Kit** **$3.95**

Sniff-It RF Detector Probe

Measure RF with your standard DMM or VOM! This extremely sensitive RF detector probe connects to any voltmeter and allows you to measure RF from 100kHz to over 1GHz! So sensitive it can be used as a RF field strength meter!

RF1 **Sniff-It RF Detector Probe Kit** **$27.95**

Broadband RF Preamp

Need to "perk-up" your counter or other equipment to read weak signals? This preamp has low noise and yet provides 25dB gain from 1MHz to well over 1GHz. Output can reach 100mW! Runs on 12 volts AC or DC or the included 110VAC PS. Assmb.

PR2 **Broadband RF Preamp** **$69.95**

Vintage Battery Eliminator
Collectors come across some great deals on antique battery-powered radios, but how to power them is a real problem. Many classic radios operated on batteries only, and in many cases a series of three batteries for each radio were required!
The new ABCE1 Battery Eliminator gives you an easy way to replace all these batteries with a simple household AC power connection and resurrect your vintage antique radios! Provides "A" filiment, "B" plate, and "C" control grid supplies, which are all isolated from each other. Complete with aluminum case. Runs on 110-240VAC.
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Digital Message System
The third generation of Ramsey digital voice storage kits! We started with the latest digital voice storage technology. It provides up to 8 minutes of digital storage at a frequency response up to 3.5 KHz. (Total message time and frequency response is dependant on selected internal sampling rate.) Once recorded, messages are available for playback on-demand or automatic continuous looping. Standard RCA unbalanced line level output is provided for easy connection to any amplifier, amplified speaker, mixer, or sound system. In addition, a standard 4-8 ohm speaker output is provided to directly drive a monitor speaker. Can be remote controlled via 3-wire BCD with our interface options. Check www.ramseykits.com for all options!
DVMS8 Digital Voice Message 8Ch Kit $99.95
DVMS8WT Assembled DVMS8 $149.95
Ultimate 555 Timers
This new series builds on the classic UT5 kit, but takes it to a whole new level! You can configure it on the fly with easy-to-use jumper settings, drive relays, and directly interface all timer functions with onboard controls or external signals.
UT5A
UT5AS
All connections are easily made though terminal blocks. Plus, we've replaced the ceramic capacitor of other timer kits with a Mylar capacitor which keeps your timings stable over a much wider range of voltages! Available in through hole or surface mount versions! Visit www.ramseykits.com for version details.
UT5A Through Hole 555 Timer/Osc Kit $24.95
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Passive Aircraft Monitor
The hit of the decade! Our patented receiver hears the entire aircraft band without any tuning! Passive design has no LO, therefore can be used on board aircraft! Perfect for airshows, hears the active traffic as it happens! Available kit or factory assembled.
ABM1 Passive Aircraft Receiver Kit $89.95
Voice Activated Switch
Voice activated (VOX) provides a switched output when it hears a sound. Great for a hands free PTT switch or to turn on a recorder or light! Directly switches relays or low voltage loads up to 100mA. Runs on 6-12 VDC.
VS1 Voice Switch Kit $9.95
OBDII CarChip Pro
The incredible OBDII plug-in monitor that has everyone talking! Once plugged into your vehicle it monitors up to 300 hours of trip data, from speed, braking, acceleration, RPM and a whole lot more. Reads and resets your check engine light, and more!
8226 CarChip Pro OBDII Monitor-Asmb $99.95
RF Preamplifier
The famous RF preamp that's been written up in the radio & electronics magazines! This super broadband preamp covers 100 KHz to 1000 MHz! Unconditionally stable gain is greater than 16dB while noise is less than 4dB! 50-75 ohm input. Runs on 12-15 VDC.
SA7 RF Preamp Kit $19.95
Touch Switch
Touch on, touch off, or momentary touch hold, it's your choice with this little kit! Uses CMOS technology. Actually includes TWO totally separate touch circuits on the board! Drives any low voltage load up to 100mA. Runs on 6-12 VDC.
TS1 Touch Switch Kit $9.95
Doppler Direction Finder
Track down jammers and hidden transmitters with ease! 22.5 degree bearing indicator with adjustable damping, phase inversion, scan and more. Includes 5 piece antenna kit. Runs on 12VDC vehicle or battery power.
DDF1 Doppler Direction Finder Kit $169.95
Mad Blaster Warble Alarm
If you need to simply get attention, the "Mad Blaster" is the answer, producing a LOUD ear shattering raucous racket! Super for car and home alarms as well. Drives any speaker. Runs on 9-12VDC.
MB1 Mad Blaster Warble Alarm Kit $9.95
Laser Light Show
Just like the big concerts, you can impress your friends with your own laser light show! Audio input modulates the laser display to your favorite music! Adjustable pattern & speed. Runs on 6-12VDC.
LLS1 Laser Light Show Kit $49.95
Retro Nixie Tube Clock
Genuine Nixie tubes popular in the 50's brought back in one of the neatest digital clocks around today! Hand made teak maple base, 12/24 hour format, soft fade-out, auto-dim, and a crystal time base at 20ppm! Tube kits also available.
IN14TM Teak Maple Nixie Clock Kit $329.95
Water Sensor Alarm
This little $7 kit can really "bail you out"! Simply mount the alarm where you want to detect water level problems (sump pump)! When the water touches the contacts the alarm goes off! Sensor can even be remotely located. Runs on a standard 9V battery.
MK108 Water Sensor Alarm Kit $6.95
USB DMX Interface
Control DMX fixtures with your PC via USB! Controls up to 512 DMX channels each with 256 different levels! Uses standard XLR cables. Multiple fixtures can be simply daisy chained. Includes Light Player software for easy control. Runs on USB or 9V power.
K8062 USB DMX Interface Controller Kit $67.95
HV Plasma Generator
Generate 2" sparks to a handheld screwdriver! Light fluorescent tubes without wires! This plasma generator creates up to 25kV at 20kHz from a solid state circuit! Build plasma bulbs from regular bulbs and more! Runs on 16VAC or 5-24VDC.
PG13 HV Plasma Generator Kit $64.95
Air Blasting Ion Generator
Generates negative ions along with a hefty blast of fresh air, all without any noise! The steady state DC voltage generates 7.5kV DC negative at 400uA, and that's LOTS of ions! Includes 7 wind tubes for max air! Runs on 12-15VDC.
IG7 Ion Generator Kit $64.95
Tickle-Stick Shocker
The kit has a pulsing 80 volt tickle output and a mischievous blinking LED. And who can resist a blinking light and an unlabeled switch! Great fun for your desk, "Hey, I told you not to touch!" Runs on 3-6 VDC.
TS4 Tickle Stick Kit $12.95
Speedy Speed Radar Gun
Our famous Speedy radar gun teaches you doppler effect the fun way! Digital readout displays in MPH, KPH, or FPS. You supply two coffee cans! Runs on 12VDC or our AC125 supply.
SG7 Speed Radar Gun Kit $69.95
Tri-Field Meter Kit
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TFM3C Tri-Field Meter Kit $74.95
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Q&A

WHAT'S UP:

Join us as we delve into the basics of electronics as applied to every day problems, like:

- ✔ Irrigation Timer
- ✔ Video Switch
- ✔ Mailbag

■ WITH RUSSELL KINCAID

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist. Feel free to participate with your questions, comments, or suggestions. **Send all questions and comments to: Q&A@nutsvolts.com**

IRRIGATION TIMER

Q I have a suggestion for a device that you might be interested in creating and including in your magazine. My wife has an extensive drip irrigation system that includes a line with spray nozzles for some hanging plants that she'd like to activate a couple of times or so a day for only brief intervals of less than a minute when the weather is hot.

The problem is that the standard irrigation timers don't allow for activation periods of less than a minute and that would apply too much water if repeated. It would be easy to design a 555 timer that would get its power when the 24V AC solenoid power is turned on by the program. The timer would activate a relay that would pass that power on to the solenoid.

If you were to publish such a circuit, it might prevent my premature death from the hands of my wife as she has lost all patience with my vague talk about solving her problem.

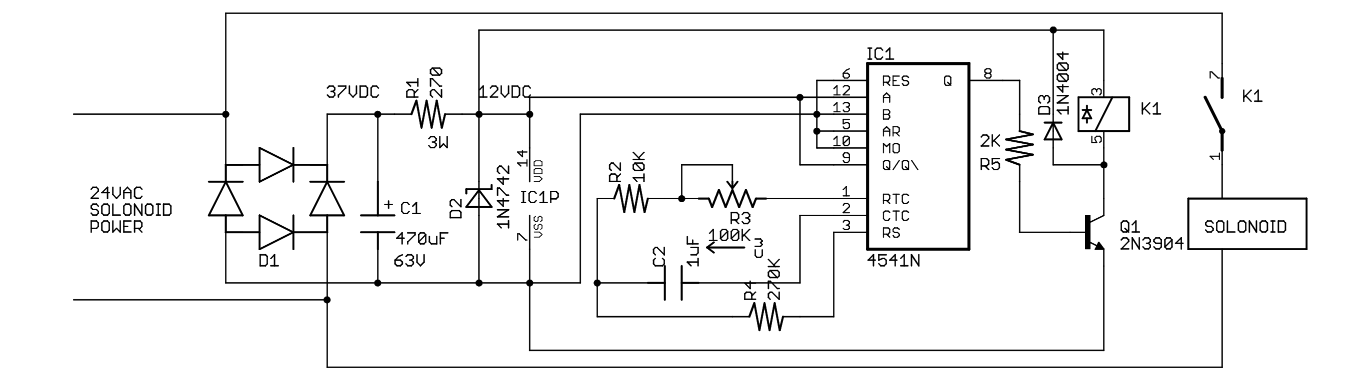
— Leo Burke

A One minute is a long time if you are holding your breath and it is a long time for a 555, although it can be done. A more reliable design can be made using a countdown timer like the CD4541 (see **Figure 1**). The oscillator is built in, the countdown is programmable, and you can choose whether the output is high or low. In this case, I chose the output to be high (pin 9 high), the countdown to be 256 (A and B programming), and therefore set the clock period to be 1/256 minute = .234 sec.

Since T = 2.3*R*C, if I choose C = 1 µF, then R = 100K. In **Figure 1**, I made the resistor, R3, a 100K pot so the time is variable from over one minute to much less.

VIDEO SWITCH

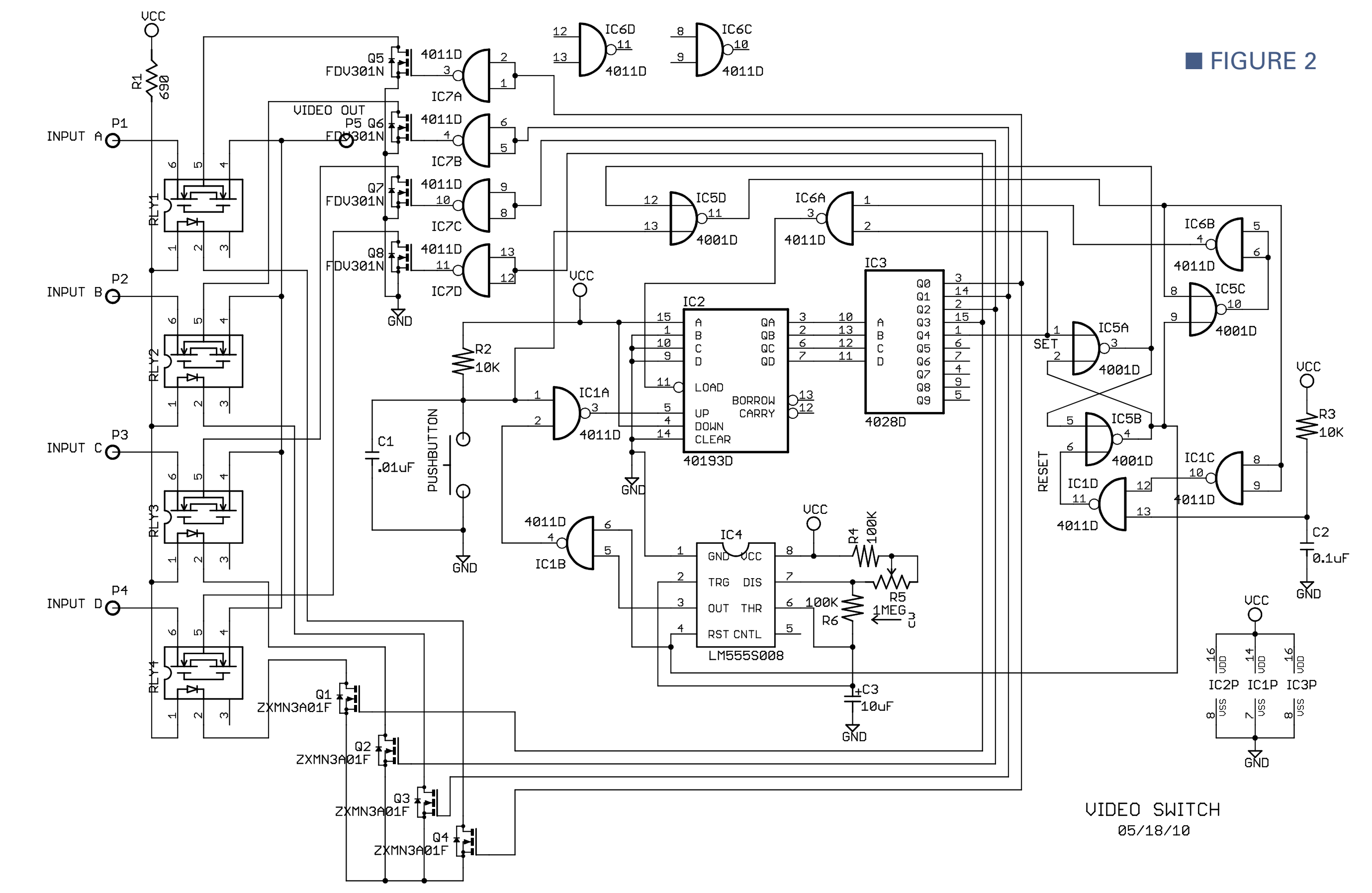
Q I need a circuit that has four NTSC video inputs and one (two matching would be nice) output. I would



PARTS LIST

PART	DESCRIPTION	MOUSER PART NUMBER	PRICE
D1	BRIDGE RECTIFIER, DIP-4	627-S1NB60-7102	0.26
D2	12V ZENER, 1W, 1N4742	78-1N4742A	0.04
D3	1 AMP, 400V, AXIAL	755-1N4004AT-82	0.49
C1	470uF, 63V, 5%, RADIAL	140-XRL63V470-RC	0.54
C2	1uF, 20V, 10%, TANTALUM	74-293D105X92TE3016A	0.11
R1	270 OHM, 3W, 5%	283-270-RC	0.39
R3	100K POT, 1/4W	31VC501-F	1.40
R2,R4,R5	1/4W, 5%, CARBON FILM	291-VALUE-RC	0.04
K1	RELAY, 12V, 10A	653-G5LE-1-DC12	0.91
Q1	NPN, 60V, 500mA	610-2N3904	0.10
IC1	PROGRAMMABLE TIMER, CD4541	512-CD4541BCN_Q	0.21

■ FIGURE 1



■ FIGURE 2

like to have a single pushbutton to select which input is at the output.

Press once to advance from input 1 to input 2, press again to advance the output to input 3, press again to advance the output to input 4, and press again to go to the hard part described next.

After advancing through each input, the next selection by the push of the button would provide an output of each video in rotation with a five or ten second delay at each input.

The rotation would sequence from video 1, then 2, then 3, then 4, and back to 1, and so on. The next push of the button would sequence back to video 1 just like in the beginning, and remain on video 1 until the button is pressed again.

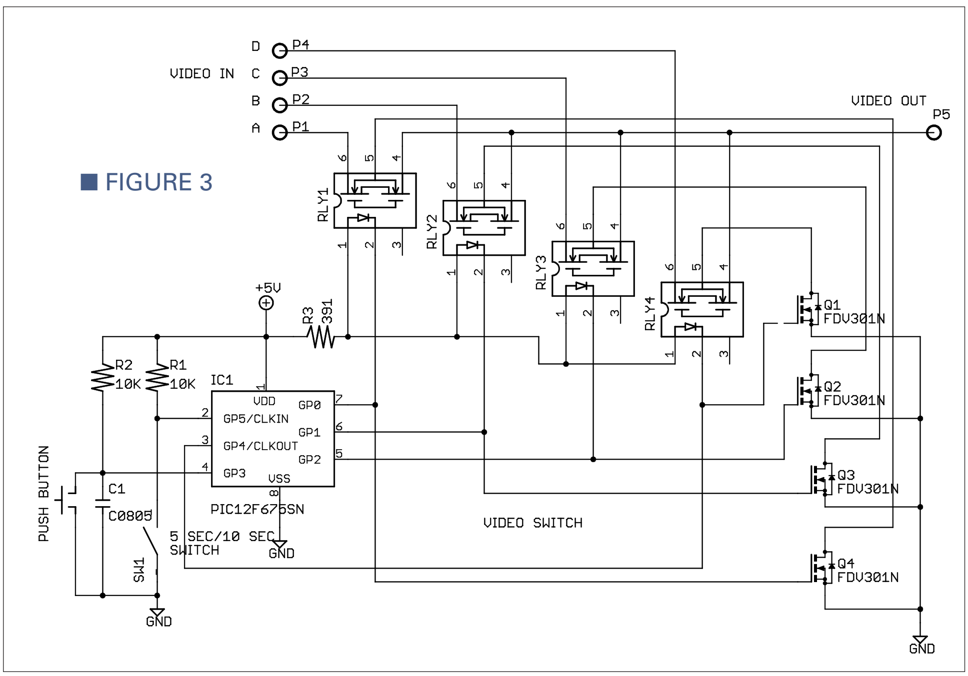
There would actually be five selections that the button rotates through, with each video as the source; the fifth would be the rotating sequence of the inputs.

I need this to be simple, compact, and lightweight.

I'm not really as concerned with the sync of the video sources as I am with ghosts of one video in the others.

— Charlie Willwerth

A I started out with a discrete logic solution (**Figure 2**) but when I described the problem to my son, he said "of course you used a micro." Looking at the complexity of the



■ FIGURE 3

discrete schematic and considering that a simple solution is desired, using a microprocessor is the logical way to go (see **Figure 3**).

In both schematics, the video switch is a solid-state relay which has an on resistance of one ohm. Although the open capacitance is not specified, I suspect it is in the range of 50 pF which simulation indicates will provide -10 dB crosstalk.

That is too much so I put a MOSFET switch from the center of the relay to ground. That improved the crosstalk to -40 dB typical or -33 dB worst case. In **Figure 2**, each press of the pushbutton clocks the up counter, which drives a 1 of 10 decoder.

When the count reaches 5, the flip-flop IC5A&B is set; at the same time, 0001 is loaded into the counter by IC6A. The flip-flop remains set until the pushbutton is pressed causing a reset. The capacitor C2 insures that the flip-flop is reset on power up. When the flip-flop is set, IC5 pin 4 is high which allows the 555 to start oscillating and clocking the counter. If anyone has issues with my logic, let me know and I will explain why I think it works (or not, as the case may be).

Figure 4 is the Parts List for the **Figure 3** video switch. In **Figure 3**, the transistors are turned off when the switch is turned on. The program is **Figure 5**; I breadboarded it and it works. The components in the Parts List should fit on a board 1.2" x 2.2".

As always, I can supply a programmed PIC12F675 for $5.00 if anyone wants to build it. **NV**

VIDEO SWITCH PARTS LIST

■ FIGURE 4

PART	DESCRIPTION	PKG	MOUSER PART #
RLY1, RLY2, RLY3, RLY4	30 VAC, 1A, 1 ohm Ron	SMD-6	630-ASSR-1411-301E
Q1, Q2, Q3, Q4	NMOS, 20V, 0.2A	SOT23	512-FDV301N_NB9V005
IC1	PIC12F675	SO8	579-PIC12F675-I/SN
R1, R2	10K, 1/8W, 1%	1206	290-10K-RC
R3	392 ohms, 1/8W, 1%	1206	290-392-RC
C1	.01 µF, 50V, 10%	0805	140-CC501B103K-RC

■ FIGURE 5

```
'*****************************************************
'* Name    : VIDEO SWITCH CONTROLLER                 *
'* Author  : RUSS KINCAID                            *
'* Notice  : FREEWARE, NO WARRANTEE                  *
'* Date    : 5/25/2010                               *
'* Version : 1.0                                     *
'* Notes   : THE SYSTEM CONTAINS 4 VIDEO SWITCHES *
'*         : CONTROLLED BY PORTS 0, 1, 2, & 4.       *
'*         : PORT 5 IS A SWITCH TO HALV THE          *
'*         : CYCLE TIME IN AUTO MODE. PORT 3 IS      *
'*         : THE DEDICATED INPUT PORT AND HAS A      *
'*         : MOMENTARY PUSH BUTTON TO FOUR ARE       *
'*         : ADVANCE THE VIDEO PORTS UNTIL ALL       *
'*         : DONE, THEN THE CONTROLLER               *
'*         : AUTOMATICALLY CYCLES THRU THE PORTS     *
'*         : PORTS UNTIL THE PUSHBUTTON IS PRESSED*
'*         : THEN MANUAL OPERATION RESUMES.
'*****************************************************
REM DEVICE = PIC12F675
REM CONFIGURATION: INTOSC, WDT DISABLED,
PWR UP ENABLED
REM MCLR = INPUT PIN, BROWN OUT DISABLED,
NO PROTECTION

ANSEL=0                 'DISABLES ANALOG INPUTS
TRISIO = %00101000      'SETS PINS AS INPUT OR
                        'OUTPUT
REM GP3 (PIN 4) AND GP5 (PIN2) ARE SET AS INPUT
REM GP3 IS A DEDICATED INPUT, I COULD HAVE SAID:
TRISIO = 0
REM AND GP3 (PIN 4) WOULD HAVE BEEN AN INPUT
ANYWAY.
DEFINE OSCCAL_1K 1        'PRESERVES OSCILLATOR
                          'CALIBRATION
                          'I DON'T KNOW HOW IT WORKS
CMCON = 7                 'SETS ALL DIGITAL MODE
IOC = %00001000           'MAKES GPIO.3 (PIN4) THE
                          'INTERRUPT INPUT

   J VAR BYTE
   X VAR BYTE
   Y VAR BYTE
        GPIO =63        'SET ALL OUTPUTS HIGH
                        'GPIO IS A 6 BIT PORT
 POO:                   'THIS ROUTINE PREVENTS VIDEO
                        'DISPLAY ON POWER UP
                        'IF YOU WANT VIDEO TO
                        'DISPLAY,
                        'DELETE THE POO ROUTINE
        IF NOT GPIO.3 THEN START      'IF PIN 4 IS
                                      'LOW THEN
START
                                      '(BUTTON IS
                                      'PUSHED)
        GOTO POO
```

```
START:
        PAUSE 1000                 'TIME TO GET YOUR
                                   'FINGER OFF THE
                                   'BUTTON
        FOR J = 0 TO 4             'J IS JUST A COUNTER
        IF J = 3 THEN J = 4        'SKIP 3 BECAUSE IT IS
                                   'AN INPUT
            X = 1 << J             'SHIFT LEFT J TIMES
(X=1, 2, 4, 16)
            Y = 63 - X             'Y=62, 61, 59, 47
HOLD:    IF GPIO.3 THEN            'AS LONG AS BUTTON
                                   'IS NOT PUSHED
        GPIO = Y                   'GPIO=111110, 111101,
                                   '111011, 101111
                                   'UNTIL NOT GPIO IS
                                   'TRUE (BUTTON IS
                                   'PUSHED)
        ENDIF
        PAUSE 1000                 'TIME TO GET YOUR
                                   'FINGER OFF THE
                                   'BUTTON
        NEXT J
            HIGH GPIO.4            'TURN OFF VIDEO#4
    LOOP:                          'AUTOMATIC MODE
            FOR J = 0 TO 3
            IF J = 3 THEN J = 4
            X = 1 << J
            Y = 63 - X
            GPIO = Y
            IF NOT GPIO.5 THEN
                    'IF 5SEC/10SEC SWITCH IS CLOSED
            FOR X = 1 TO 10
                         'DELAY 10*500= 5 SECONDS
            IF NOT GPIO.3 THEN
              'CHECK EVERY 500mS FOR BUTTON PRESS
            GOTO START : ENDIF
            PAUSE 500 : NEXT X
            ELSE
                     'IF 5 SEC/10SEC SWITCH IS OPEN
            FOR X = 1 TO 20
                          'DELAY 20*500 = 10 SECONDS
            IF NOT GPIO.3 THEN
              'CHECK EVERY 500mS FOR BUTTON PRESS
            GOTO START : ENDIF
            PAUSE 500 : NEXT X
            ENDIF
            NEXT J
            GOTO LOOP
                     'REPEAT UNTIL BUTTON IS PUSHED
END                                   'FINALLY!
```

MAILBAG

Dear Russell: Re: Cheap Strobe, April '10, Page 22.

I have been reading *Nuts & Volts* for years and I have enjoyed your circuit problem solutions, but I think that you may have rushed the answer to the "camera flash conversion" question making the circuit more complex than it needs to be. I finally feel qualified to speak on a subject in your column.

Several years ago, I experimented at length with this very idea intending to build 700 strobes for my Christmas display. While it worked out in the end (yes 700 built), I would not recommend doing it this "free" way. Here is what I discovered:

While Kodak cameras were plentiful, their circuit was not capable of sustained flashes without burning out the charge pump transistor. Fuji camera circuits were much better and the smaller board was easier to package in a clear tube.

To trigger the flasher automatically, use a SIDACTOR across the contacts that flash the camera. The item I used was a 110-125 UBO one amp TO-92 (K1200E70-ND) from Digi-Key ($.60; not free). Initially, this produces a flash every one to three seconds depending on the tolerances of the other components.

The camera capacitor takes about seven seconds to charge. I was able to cut that time down to three seconds by using two caps in series. A better solution was to replace the cap with a 10 µF 350 volt Xicon unit.

Flash rates increased to about one to two seconds. These were available from Mouser at a very reasonable price ($.22). I see now where this item costs a lot more and is on the discontinued list. The original camera capacitor energy caused the flash tube to darken and fail prematurely.

Charge current is about three amps until a charge is built up. Some current limiting occurs because of the internal resistance of the battery. Running a circuit from a high current supply for a few minutes will cause the circuit to fail. Running with a 0.1 ohm three watt (surplus) power resistor in series works, but the power dissipated in the resistor is enough to cook your breakfast.

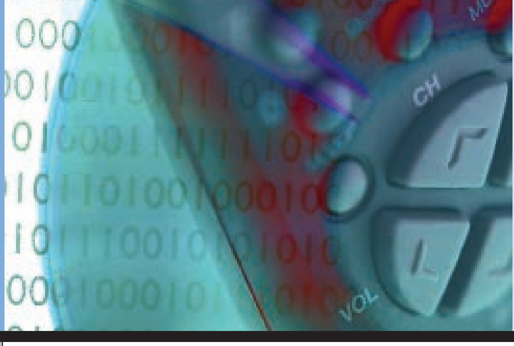
The practical solution I came up with was to run a line of three or four flasher units in series with each other from a five volt 30 amp supply (not free). These lines were powered from a heavy feeder running along the ground. I found these at the usual online surplus vendors.

The flashers were to be hung from the same wire that carried the power. They had to be visible from whatever direction they happened to be oriented in. To make it omni-directional, I removed the flashtube reflector and soldered the tube directly to the end of the circuit board.

A thin trigger wire was wrapped around the tube-restoring the electrical function of the shield. Cooling is still a consideration so running the flashers in cold weather is good.

The flashers are good for about four seasons. The flash rate will slow down with age and eventually stop, but replacing the xenon tube will get it back online.

— J.M. Keller



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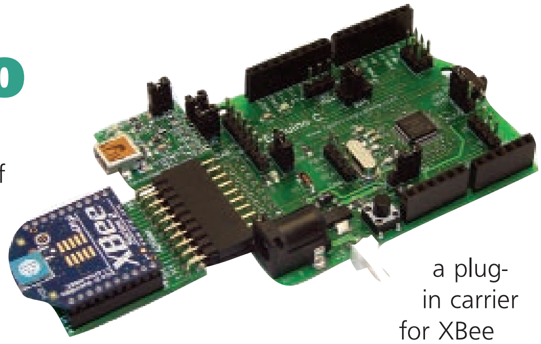

Technological Arts introduces Esduino12, the first in a line of new products conforming to the popular open-source Arduino hardware form-factor. Based on the popular 16-bit Freescale 9S12C microcontroller, Esduino12 offers enhanced capability and programming flexibility over existing Atmel-based designs, yet retains hardware compatibility with the growing number of available Arduino application shields.

Esduino12 is programmable in assembler, BASIC, and C. For assembler and C programming, Freescale's free Special Edition of CodeWarrior for Windows is a popular choice. For those who prefer BASIC, the object-based Windows-hosted nqBASIC language is available free of charge from **www.nqBASIC.com**.

With a base price of only $39, Esduino12 offers plug-in options for both USB and wireless XBee communications (no shield required), and provides simple three-way routing that enables the user to choose USB-to-XBee, USB-to-MCU, or XBee-to-MCU communications. Both 3.3V and 5V regulators are provided on-board, giving added utility to the design.

While a standard BDM connector is provided for advanced users, the Freescale Serial Monitor (i.e., bootloader) comes factory-programmed into the 9S12C chip so that a BDM pod is not required for basic erasing and programming operations.

Two product configurations are being offered: #ESD12C32 ($39) with 32K Flash and 2K RAM and #ESD12C128 ($49), with 128K Flash and 4K RAM. The optional USB-to-TTL interface (#USB2MCU) is $15.50, and a plug-in carrier for XBee modules (#ADXB-RA) is $7.50.

For easy implementation of custom applications, a selection of four new Arduino-compatible $10 prototyping shields has also been announced. These shield designs maximize use of the available board area, and are optimized for applications involving narrow and wide DIP packages, LED displays, and discrete through-hole components.

For more information, contact:
Technological Arts
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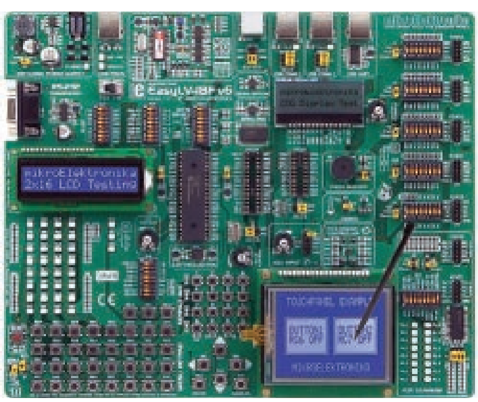
PIC18J and PIC18K DEVELOPMENT SYSTEM



MikroElektronika announces the release of the EasyLV-18F v6 Development System which allows users to develop and design devices using Microchip PIC18J and PIC18K series microcontrollers. The new system supports 40-, 28-, and 20-pin PIC18FxxJxx (PIC18FxxKxx) devices. The board includes features such as a USB 2.0 programmer with mikroICD and many peripheral modules such as: serial RAM, serial EEPROM, serial COG display, piezo speaker, etc.

Each feature of the board is supported by example written in mikroC, mikroPascal, and mikroBasic PRO for PIC compilers. Also, the tool comes with full color printed documentation. **www.mikroe.com/eng/products/view/477/easylv-18f-v6-development-system**.

mikroElektronika also announces a new book called *PIC Microcontrollers – Programming in BASIC*. With it, you can learn about programming the PIC microcontroller in BASIC with practical projects, clear illustrations, and detailed schematics provided. This book shows you step-by-step how to easily program PICs and is printed in full color, so it is very easy to read and understand.

For more information, contact:
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continued on page 77

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THERMOELECTRIC POWERED SUNFLOWERS

By John Iovine

For warm summer evenings, I thought it would be cool to have some pool flowers floating around to create a nice ambience. To make it even cooler, I wanted to use the sun to power them. I've always wanted to work with thermoelectric effects, so I combined these two desires.

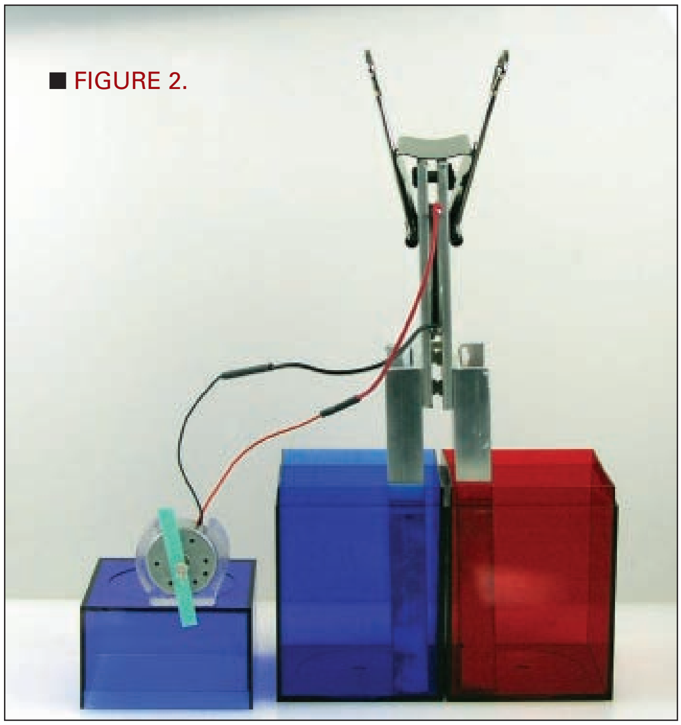
In 1821, Thomas Johann Seebeck discovered the thermoelectric effect which is the generation of electric current from heat. He discovered when a junction of two dissimilar metals are heated through a temperature gradient, the junction produces a small but measurable electric current. By twisting the ends of two dissimilar metal wires to produce an elongated junction, one can create a junction that produces a few millivolts.

Inversely, when a voltage is applied to this junction, it creates a temperature difference. This was discovered in 1834 by Jean Charles Peltier and is known as the Peltier Effect. Together these combined effects are called the Peltier–Seebeck effect and form the basis of thermo-electric generators (TEG) and thermo-electric cooling (TEC).

Modern thermoelectric generators use PN junctions manufactured from semi-conductor materials instead of dissimilar metals (see **Figure 1**). However many thermocouples still use dissimilar metals for their construction.

There are a number of electronic companies that offer surplus TEC modules (see **Sources**). Many TEC modules can be used as TEG modules, although a TEC pressed into service as a TEG will have a lower efficiency than a TEG module. However, a TEC still works well enough as a demonstration model.

■ FIGURE 2.



■ FIGURE 1.

Building a Thermoelectric Generator

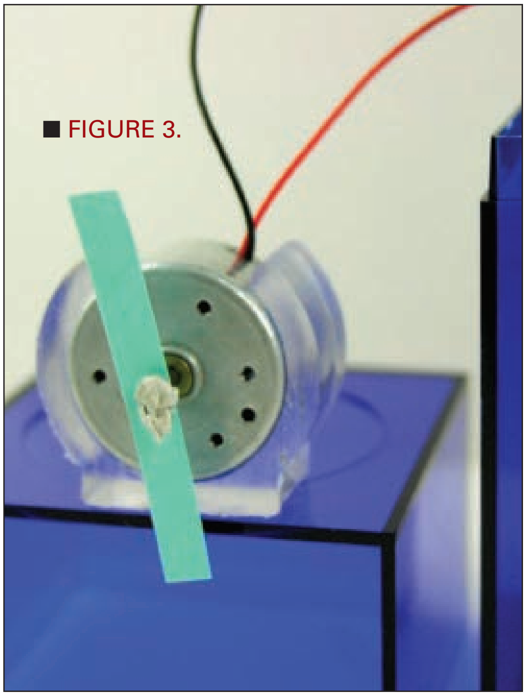
To operate a generator, we need to heat one side of the TEG while simultaneously cooling the opposite side. This is achieved by securing two aluminum leg extrusions spring-clamped to each side of the TEG module. The aluminum legs transfer heat and cold from the water baths to the module. One aluminum leg extends down into a hot water bath and the other

extends into a cold water bath. This is shown in **Figure 2**.

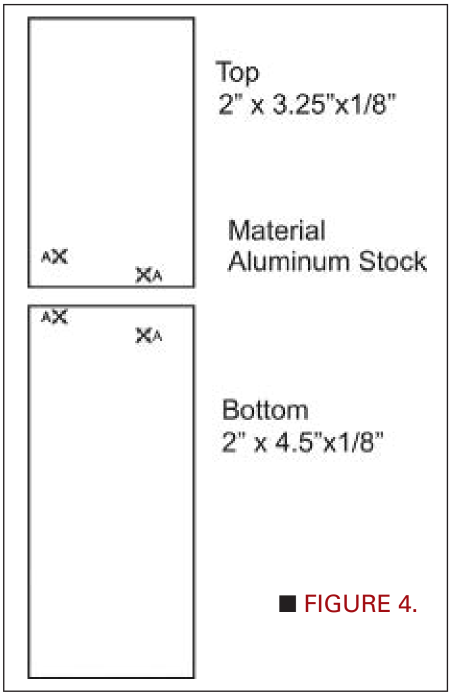
After about a minute from the time the legs are submerged into the water baths, the TEG generates sufficient electric power to spin a homemade paper propeller on a high efficiency, low power electric motor (see **Figure 3**).

Not all small electric motors will work, however. You need a motor that requires only a small amount of power to function. You can try a cassette motor if you have one available. Otherwise, you can pick up a motor from the **Sources List**.

The aluminum legs are each made up of two smaller 1/8" thick aluminum plates as in **Figure 4**. Two machine screws 4-40 x 3/8"and nuts hold the plates to make up a leg.



■ FIGURE 3.



■ FIGURE 4.

The components for the Thermoelectric generator are illustrated in **Figure 5**.

Once the legs are assembled, they can be secured to the TEG using a large spring paper clip. The electrical leads from the TEG are soldered to the high efficiency, low power motor mentioned earlier. Two water canisters are needed for the hot and cold water baths. The rectangle shape allows the containers to be positioned next to one another. This allows the legs — which only have about 1/2" space between them — to slide into the hot and cold water baths simultaneously.

Fill the cold side with cold water and ice cubes. Fill the hot container with boiling hot water. Place the legs of the thermoelectric generator into the water baths.

Aside from powering an electric motor, you can also use a multimeter to measure voltage and current output of your TEG module.

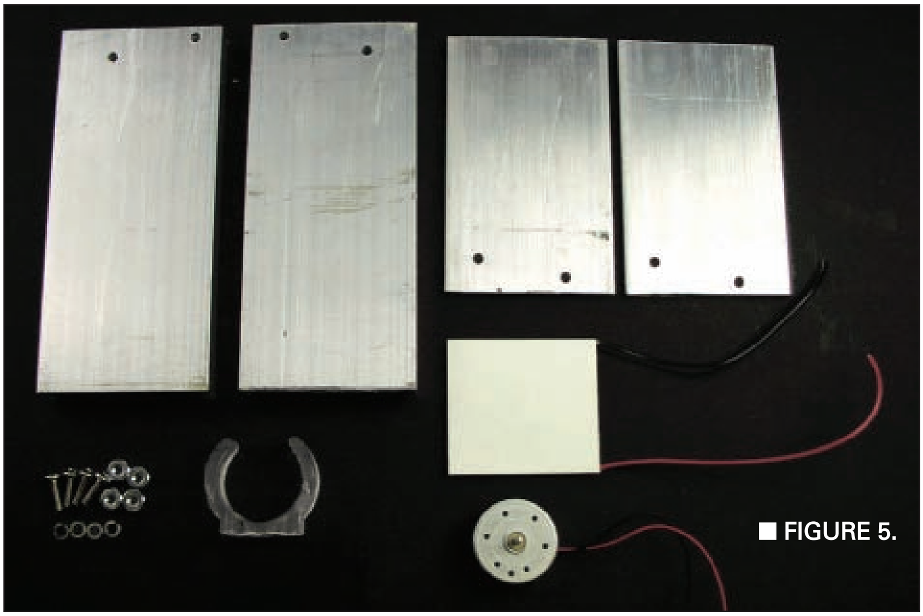
Thermoelectric Sunflower

To further demonstrate how our TEG module works, we'll construct a sunflower. This sunflower is a passive solar device that uses the warmth from the sun to heat the hot side of the TEG and cool ocean water or cool water in your salt water pool to cool the opposite side see **Figure 6A**.

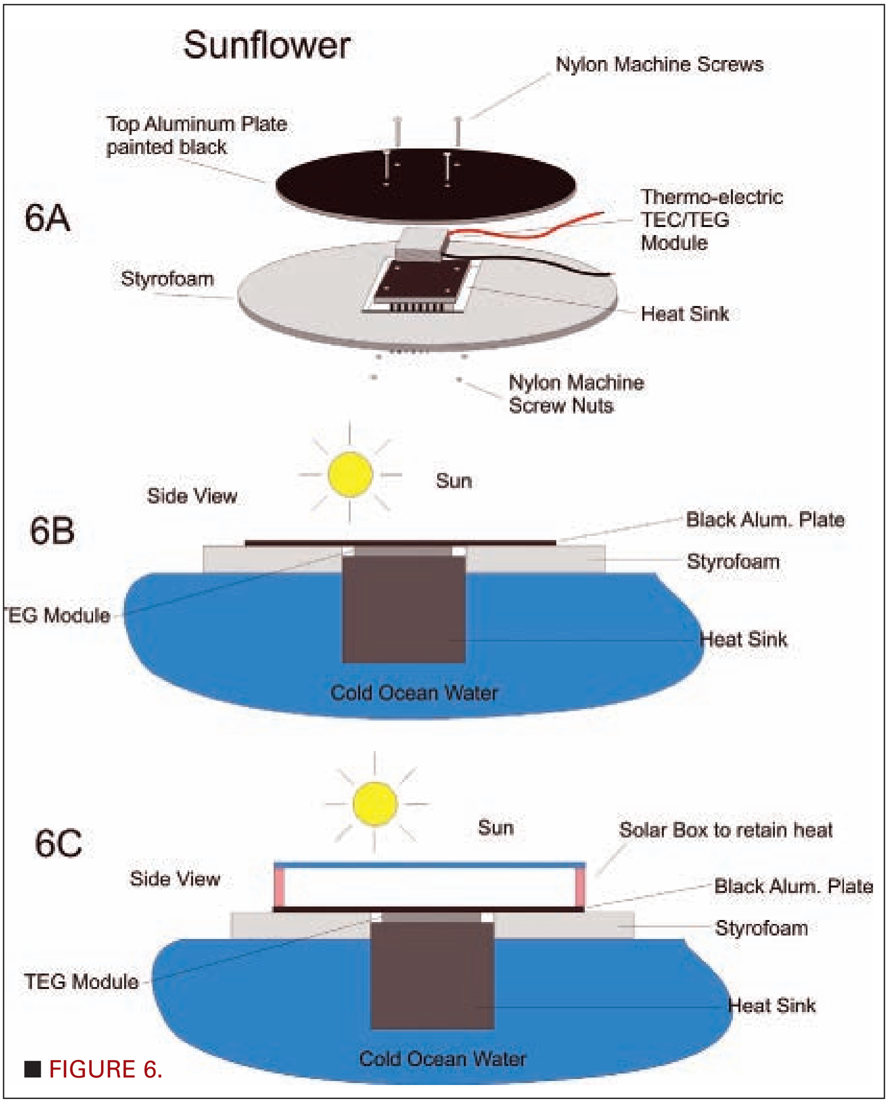
An aluminum plate is attached to the hot side of the TEG module. The top side of the aluminum plate is painted with a high temperature black paint to improve heat absorption from the sun. Next, Styrofoam is attached to the bottom side of this plate. I used a spray adhesive on the aluminum plate to secure it.

The Styrofoam performs two functions: one as a flotation device to keep the aluminum plate and TEG module floating in water; and the second as insulation to keep the water from touching and cooling down the aluminum plate. (The Styrofoam may degrade from the heat of the aluminum plate baking in the sun, but for my prototype, I'm checking function, not longevity.)

On the opposite side of the TEG module, a large deep heatsink is attached. This heatsink is partially submerged in



■ FIGURE 5.



■ FIGURE 6.

Sources for Parts

Surplus Thermoelectric Modules
www.bgmicro.com
www.allelectronics.com
www.mpja.com/

Aluminum Bar Stock, Screws, Nuts, Aluminum Plates
McMaster-Carr
www.mcmaster.com/

High Efficiency Electric Motor and Rectangular Plastic Containers
www.imagesco.com

the cold ocean water. This keeps the heatsink cool which, in turn, keeps the cool side of the TEG module cold.

Float the Sunflower in ocean (salt) water and allow time for the top aluminum plate to get hot in the sunlight. Within a few minutes, the TEG will begin to generate electric power.

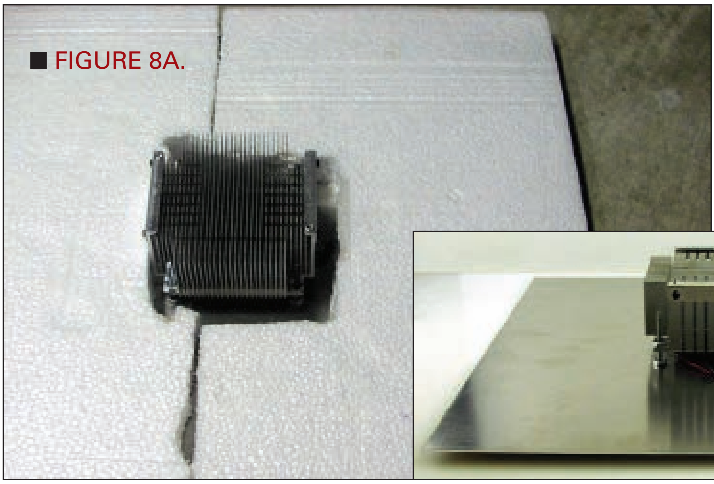
To improve the efficiency of the sunflower, you can increase the amount of heat captured by covering the black aluminum plate with glass with a two inch dead air space — like in a flattened solar oven or solar water heater (see **Figure 6C**). This will reduce heat loss from the black plate to the air and wind, making our sunflower far more efficient.

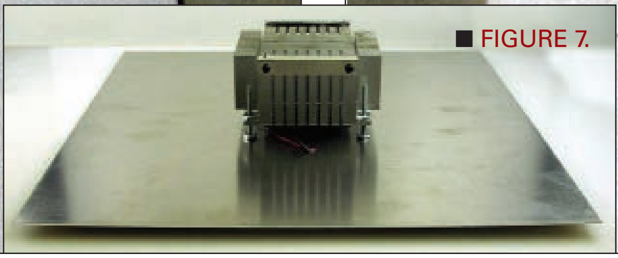
Figure 7 shows the prototype sunflower under construction. Note the heatsink and the TEG attached to the bottom side of the aluminum plate. **Figure 8** shows the Styrofoam glued to the bottom surface.

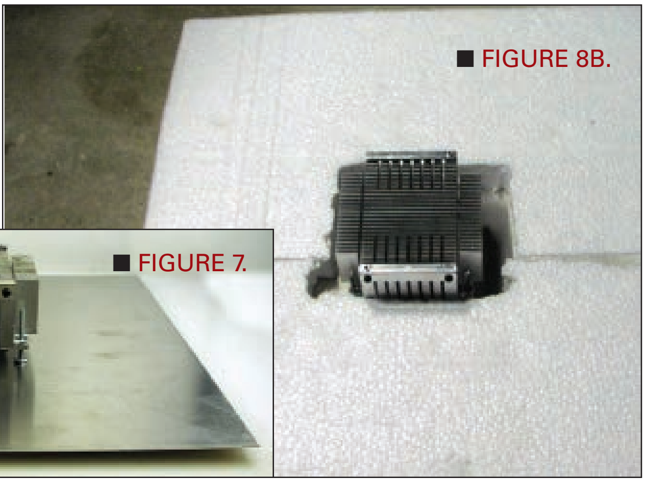
Figure 9 shows the top side of the prototype with the two electric power wires from the TEG module.

I used a rectangle piece of aluminum in my prototype since this was easier to purchase than round shaped aluminum.

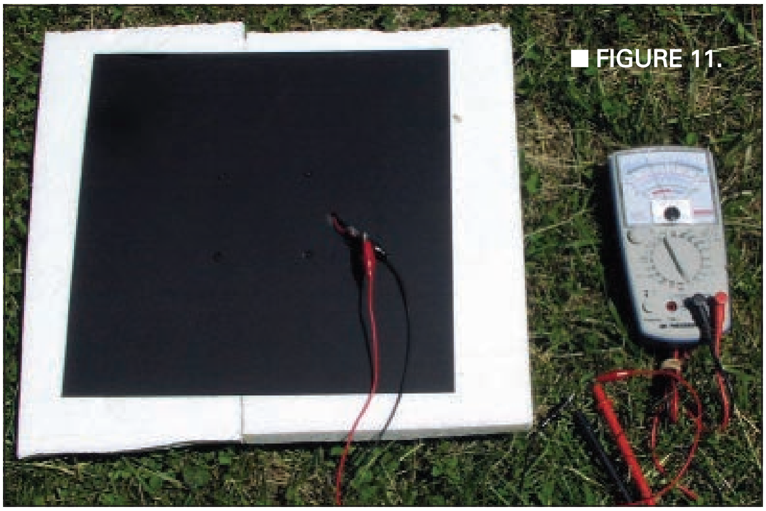
I am waiting for summer to fully test my prototype. I'll post the results on my company's website (**www.imagesco.com**) once I have them.


■ FIGURE 8A.


■ FIGURE 7.


■ FIGURE 8B.

■ FIGURE 9.



■ FIGURE 11.

■ FIGURE 10.

■ FIGURE 12.

The Future of Thermoelectric

Volkswagen and BMW have manufactured a line of thermoelectric generators that are powered by the waste heat of their car's internal combustion engine. By doing so, they can use a smaller alternator on the engine for its electrical power needs. This contributes to the car's improved efficiency by reducing the work required by the engine.

Pre-Summer Tests Results

This May wasn't a particular sunny or hot month in New York City. I did have a few 80 degree plus days to bring the sunflower out for some preliminary real world testing, however. I used a cooking pan filled with ice and water to be sure it stayed cool enough out in the ambient temperature (**Figure 10**).

I placed the sunflower's heatsink into this pan and left it in the sun for 15 minutes before I began taking some power output measurements from the TEG module (see **Figure 11**).

The voltage output at 15 minutes was approximately 0.8 volts (**Figure 12**). At the half hour mark, I checked the current output and it was an impressive 160 mA — far more current than I had expected.

Going Further

The sunflower has not been completely optimized. To further develop this project, I would do heat studies relating to the thickness of the aluminum material. The current sheet size may be large enough to handle two or three (possible four) TEG modules at a time. A little thought and ingenuity can make this even more impressive. I'd love to have several of these floating in my pool for a great evening ambience. **NV**

MAKE THE BIKE BLINKER PLUS

BY DAVID G. BODNAR

■ PHOTO 1.

As a cyclist, I frequently start bicycle rides long before sunrise. This has motivated me to have an interest in lightweight and efficient bicycle lighting systems. I also have an interest in LEDs and microcontrollers as they relate to my model railroading endeavors (see http://trainelectronics.com). I recently combined both interests and developed what I feel to be a unique helmet mounted LED lighting system that not only alerts drivers to my being on the road, but provides me and my fellow cyclists with some useful information as we ride.

In order to give motorists the best chance of seeing my lights, I like to have at least some illumination on my helmet. This is usually the highest point on a cyclist and the most likely to be noticed. The first version of this lighting system was made by mounting three bright white LEDs on the front of my helmet and three bright red LEDs on the back. It was a simple flashing circuit using a PIC12F683. A single pushbutton switch allowed for the selection of a number of different flashing modes and sequences. While this worked well, it did little more than what was available with many commercial units.

Something More than Just Illumination!

I live in Pittsburgh and do a good bit of my bike riding in the winter. As you can imagine, temperature is always of interest and a topic of conversation before, during, and after each ride. I normally carry some sort of digital thermometer on my bike rides and I frequently hear other cyclists yelling out "Dave, what is the temperature now? It must be well below freezing!"

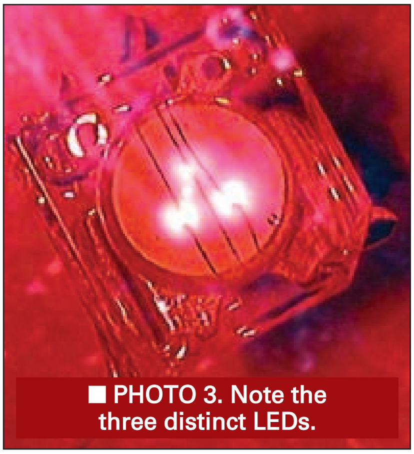
I don't mind being the resident temperature reporter in the peloton but it occurred to me that the flashing lights on my helmet could be used to relieve me of this duty. By incorporating a thermal sensor into the circuit and coming up with a way to report its output with the helmet lights, I would have an automated system that would take care of continuously reporting the temperature. Thus was born the **Bike Blinker +Plus+**.

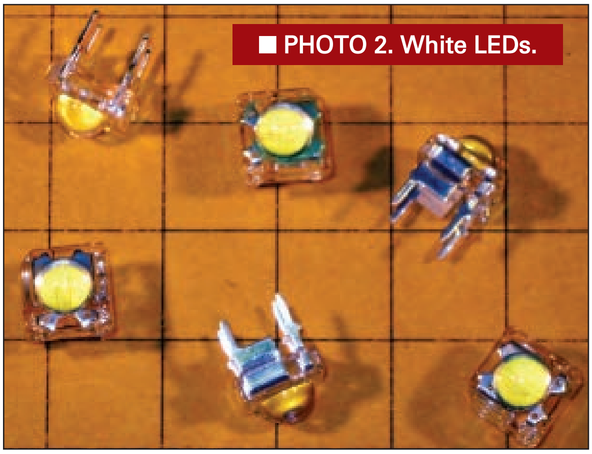
Objectives

My years as a classroom teacher proved to me the value of setting objectives before starting a lesson or any other project. The objectives for the Bike Blinker include that the unit will:

- Accurately measure and report the temperature.
- Report the temperature in a way that is easy to understand.
- Be configurable to report the temperature in

Fahrenheit or Celsius.
- Have an option to report the minimum and maximum temperature observed.
- Drive several bright red and white LEDs.
- Operate from a 3.7 volt lithium-ion battery or any other power source that can supply three to five volts.
- Run continuously for at least two hours.
- Have a pushbutton switch to set options and to select the flashing mode.
- Accommodate at least four operating modes.
- Be small enough to be mounted on or inside of the vents of a helmet or in a small enclosure.
- Be light enough to be unnoticed by the user.


■ PHOTO 3. Note the three distinct LEDs.


■ PHOTO 2. White LEDs.

The LEDs

The three white LEDs that I placed on the front of the helmet are 1/2 watt devices that are unusually bright (see **Photo 2**). Each 5 mm LED enclosure contains three discrete LEDs. **Photo 3** was taken through a red filter and shows one of the LEDs operating at a very low voltage. Because the intensity of the LED's light has been dramatically diminished, you can clearly see the three points of light from each of the LEDs and the wires that are connected to them.

These LEDs provide a very bright light and each one only draws about 60 ma; they can be clearly seen in **Photo 1** which shows the front of the helmet.

The red LEDs for the rear are also rated at 1/2 watt. They are 10 mm units that throw a bright directed beam. One red LED faces straight back with the other two being aimed a bit to the sides. This arrangement gives maximum visibility. The vent to the right in **Photo 4** houses the circuit board and the sensor.

The Temperature Sensor

Temperature readings come from a Dallas Semiconductor DS18B20. This device uses a 1-wire protocol to communicate with the microcontroller and is factory calibrated to an accuracy of ± 0.5 degrees C. Routines to read these sensors are readily available on the web and I had no difficulty interfacing it to the PIC.

Getting Power to the LEDs

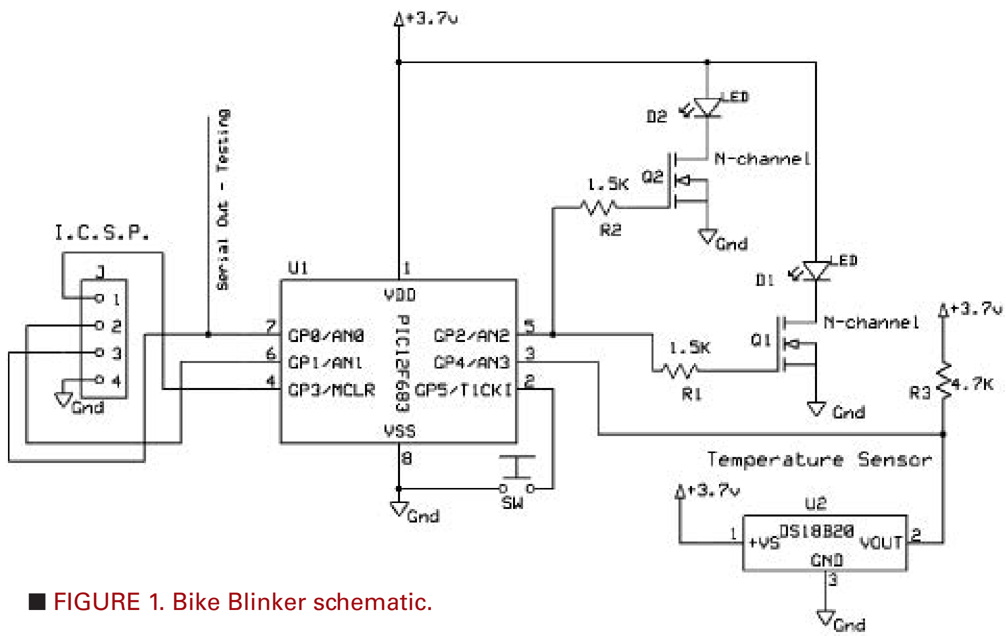
The LEDs that I am using draw much more current than the microcontroller can supply from its output pins. A transistor is inserted between the microcontroller's output pins and the LEDs to provide the necessary current. Any general-purpose NPN transistor should work. My first design used two 2N2222 transistors. I could have gotten away with using only one transistor but decided that it would be simpler to use one transistor to drive the three front LEDs and another to drive the three rear LEDs. This effectively doubled the current handling capacity and saved me from experimenting with series resistors that were needed to match the different LEDs so that they could be operated by a single transistor.

This arrangement worked quite well and was used for several months. I continued to experiment with the circuit and discovered that I could improve battery life and LED brightness by replacing the 2N2222s with N-channel MOSFETs. The 2N2222 transistors have a fairly high internal resistance and dropped the voltage to the LEDs by well over 0.5 volts. MOSFETs, on the other hand, have a very low internal resistance and there was very little voltage drop through them. I was pleased to find that the MOSFETs worked well when substituted for the 2N2222s without any changes to the circuitry (see **Figure 1**).

The Microcontroller

A PIC12F683 ties the hardware together by reading


■ PHOTO 4. Helmet back.



■ FIGURE 1. Bike Blinker schematic.

the temperature sensor and a single pushbutton switch while operating the flashing LEDs. I have used this chip for a number of model railroading projects and knew that it had more than enough capability for this endeavor. I also knew that the eight-pin 12F683 was available in a surface-mount package that would go a long way towards meeting one of the objectives — making the unit as small and lightweight as possible.

Construction

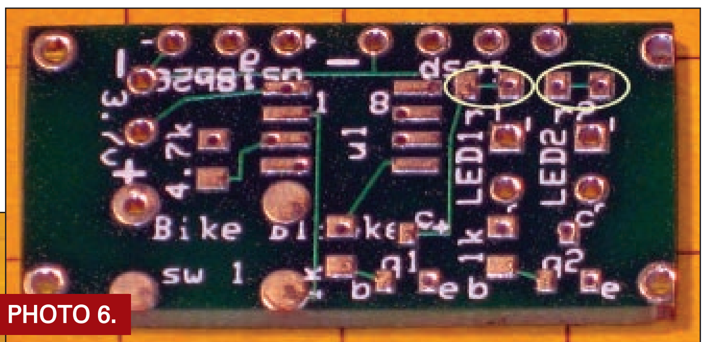
Solder the PIC12F683 to the circuit board; sure to align pin 1 properly. To check the wiring, I like to program the chip as soon as it is mounted. Just connect power (three to five volts DC) to the board and plug in a four pin header to the ICSP (in-circuit serial programming) connection. Successful programming will confirm that the chip has been installed correctly.

Next, add the 4.7K resistor and DS18B20 temperature sensor. Note the pin position of the sensor. The flat side of the device goes towards the center of the board (see **Photo 5**).

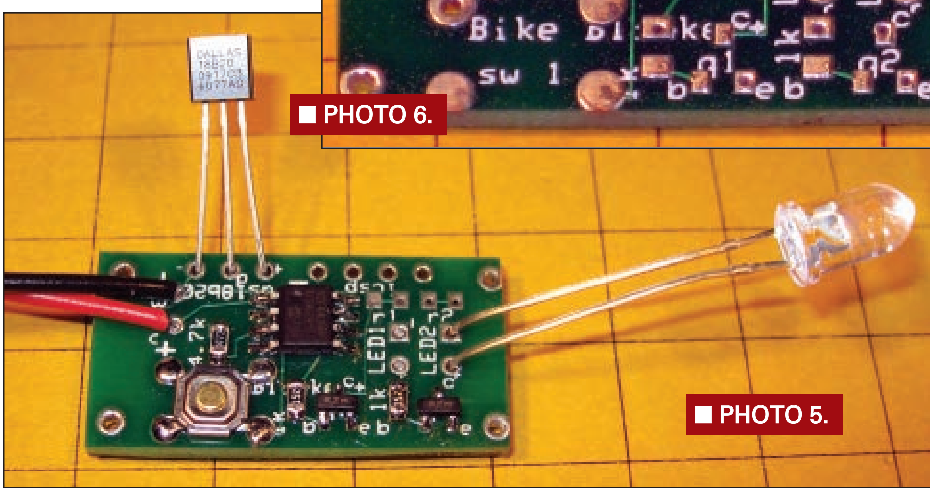
Attach the resistors (1K or 1.5K) and MOSFETs to the board. There is a spot on the board where a resistor can be added for each LED. This set of pads is jumpered by a small trace (circled in **Photo 6**) in the event that you don't need a current limiting resistor. If one is to be used, you must cut that connecting trace before adding the resistor. I have run the unit using the LEDs shown here without current limiting resistors and have had good results. If you increase the input voltage to five volts, you would surely need to add 50 or 100 ohms in series with the LEDs to keep from damaging them.

The pushbutton switch needs to be oriented with its longer axis in line with the longer axis of the board. If you choose to use an external switch, its wires connect to the upper left pad (the one with the hole in it) and the one in the lower right (next to the "1" in "sw 1").

Connect your LEDs to the board and apply power. The current Fahrenheit temperature should begin to display.



■ PHOTO 6.



■ PHOTO 5.

Using the Serial Output for Testing

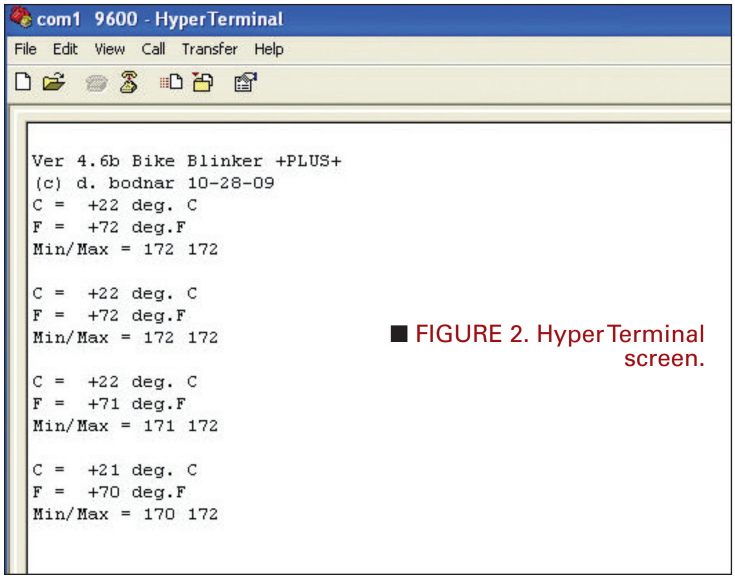
Pin 7 and ground can be connected to a PC's serial port for testing. The PIC's pin 7 goes to pin 2 on the PC's DB9 serial port connector and ground goes to pin 5 on the DB9. On your PC, set HyperTerminal for 9600 baud, eight bits, one stop bit and, no parity. When power is applied to the completed Bike Blinker, the version number and current Celsius and Fahrenheit temperatures should be displayed (see **Figure 2**).

Comments in the PICBASIC PRO program listing (available at **www.melabs.com**) explain why the

"Min/Max" temperatures shown on the HyperTerminal screen are 100 more than their actual values. They are stored on the PIC this way to accommodate negative temperatures on a device that does not normally understand negatives.

The Software

The program for the PIC12F683 is written in PICBASIC PRO. The code (available at **www.nutsvolts.com**) is well documented and should be fairly easy to follow. You will also note that there are a number of "SEROUT" commands. These send information to the device's serial port and were used for debugging as they give information on the program's operation. If more program space is needed for additional modes or features, the serial commands can easily be removed.



■ FIGURE 2. HyperTerminal screen.

Reading the Temperature

The objectives state that the temperature must be reported in a manner that is easily understood. Being an amateur radio operator, my first inclination was to use Morse Code for the numbers but the thought of teaching the sequence of dots and dashes to my riding comrades convinced me to search for another alternative. The simplest code I could come up with has proven to be easily understood by everyone who sees it.

A temperature report always starts with a rapidly blinking sequence where the LEDs flicker for a half second or so. Next, the number of hundreds of degrees is displayed followed by a short pause, the number of tens, another pause, and the number of ones. The software suppresses the reporting of hundreds of degrees if the temperature is below 100. When reporting numbers of degrees, the LEDs flash at a rate of about 1/3 second on and 1/3 second off. When reporting a zero, they flash on and off much more rapidly. These rates can easily be changed in the software but have worked well throughout a full year of testing.

The temperature reports are the same whether they are reporting in Fahrenheit or Celsius. You must remember which scale you have the unit set to report.

One Button Does It All!

A single SPST momentary switch takes care of all the mode and configuration changes. The unit currently has

To Report 103 Degrees: (Uncommon, but not unheard of in Pittsburgh!) • Flicker • Flash once • Pause • Flash once very briefly to show a zero • Pause • Flash three times • Repeat	**To Report 48 Degrees:** • Flicker • Flash four times • Pause • Flash eight times • Repeat	**To Report 7 Degrees:** • Flicker • Flash once very briefly to indicate zero tens (I could suppress this but a two "digit" report seems to work best.) • Pause • Flash seven times • Repeat
To Report 0 Degrees: • Flicker • Flash once briefly (zero) • Flicker • Flash once briefly (zero) • Repeat	**To Report 7 Degrees Below Zero:** (The coldest Fahrenheit ride we have ever done!) • Flicker • LEDs gradually go from full bright to dim to off to indicate a negative temperature • Flash once very briefly to show zero tens • Pause • Flash seven times • Repeat	**The Minimum/Maximum Temperature Reports (mode 5) Work as Follows:** • Current temperature is reported as above • LEDs gradually go from full bright to dim to off to indicate that the minimum temperature is coming • Flicker • Minimum temperature is reported as above — note that a negative minimum temperature would again be preceded by dimming LEDs • LEDs gradually go from off to dim to full bright to indicate that the maximum temperature is coming • Flicker • Maximum temperature is reported as above • Repeat

five different operation modes:

1. Continuously display temperature in Fahrenheit or Celsius.
2. Blink rapidly (approximately eight times per second).
3. Blink slowly (approximately one time per second).
4. LEDs on (no blinking) — great for fixing flats in the dark; not so good for battery life.
5. Display the current temperature, then the minimum temperature that has been seen since the unit was turned on, then the maximum temperature that has been seen since it was turned on. The current temperature is shown in the normal manner. The minimum temperature report is preceded by the LEDs slowly going from full brightness to dim; the maximum temperature report is preceded by the LEDs slowly going from dim to full brightness.

When the button is pressed, the LEDs flash the number of the new mode. If the button is held, the mode number is flashed repeatedly. Releasing the button initiates operation using the newly selected mode. There are several other functions that the button controls:

1. If the button is held for a few seconds as the unit is turned on, the temperature reports change from Fahrenheit to Celsius or from Celsius to Fahrenheit. The current mode is reported by flashing either a Morse Code "C" [long flash, short flash, long flash, short flash] or a Morse Code "F" [short, short, long, short].
2. If held long enough for the mode selection to flash five times, the LEDs will slowly dim and go out, and the unit will turn off.
3. Pressing the button while the unit is off will turn the unit back on (indicated by the LEDs slowly going from off to full brightness).

The blinker doesn't fully turn off when the button is held down as described above. It enters a very low power sleep mode. An on/off switch can be added to the circuit to completely turn the power off. This may be desirable as the batteries will slowly be exhausted if the unit is left in sleep mode for weeks or months.

If you do not install an on/off switch, you can still change the Celsius/Fahrenheit scale by putting the unit to sleep, then holding the button down when you turn it back on. The current temperature scale will be displayed after the unit awakes. Continue holding the button and it will change to the other scale. The mode is saved when the unit goes to sleep or is turned off so that it returns to the last selected mode when it restarts. A video is available on the *Nuts & Volts* website that shows the operation of the unit in its various modes.

Battery Choices

I operate my helmet lights with 3.7 volt rechargeable lithium-ion batteries that were designed for cell phone or PDA use. The circuit will also work well with any power source that supplies from three to five volts. Three rechargeable NiHM AA or AAA cells in series work well. If you opt to use a voltage greater than 3.7 volts, you may need to add current limiting resistors in series with the LEDs. Their value will vary depending on the LEDs you choose and the voltage of the batteries.

Mounting Options

As you can see from the **photos**, I mounted the LEDs and blinker circuit inside of the vents of my helmet. The three white LEDs were mounted inside of the front vents with hot melt glue and the red LEDs were similarly glued inside of the rear-facing vents. The circuit board was mounted with double-sided foam tape inside of a top vent and the battery was mounted with Velcro™ to the top rear of the helmet. This arrangement works very well and gives the system a nice integrated look.

I put the DS18B20 on the end of a short piece of three-conductor ribbon cable so that it is a few inches from my scalp. Even then, the temperature tends to go up when I stop at a traffic light on cold days as it senses my body temperature.

PARTS LIST

ITEM	DESCRIPTION/PART NUMBER	SOURCE
White LEDs	5 mm 0.5W MultiChip White Flux LED 50 Kmcd	eBay seller Ivehk
Red LEDs	10 mm HIGH POWER 0.5W RED LED LAMP 150,000 mcd	eBay seller Ivehk
Microprocessor	**Digikey.com** - Part #PIC12F683-I/SN-ND	PIC12F683
Temperature Sensor	**SparkFun.com** - Part #SEN-00245	DS18B20
N-Channel MOSFET	Digi-Key Part #eMMBF170LT1GOSCT-ND	
Switch	Electronic Goldmine - Part #G13795	SPST momentary
Resistor R1 & R2	Electronic Goldmine - Part # G255R	1K or 1.5K SMT
Resistor R3	Electronic Goldmine - Part # G266R	4.7K SMT
Resistors	Electronic Goldmine - SMT 1206	none or to match your LEDs
	www.goldmine-elec.com	
Circuit board file	*Nuts & Volts* website	

The mode button is also mounted externally by wiring a second SPST momentary switch at the end of the vent. This makes it much easier to change modes while riding.

For those of you who would like a less permanent installation or would like to have the option of moving the light from helmet to helmet, you can easily mount the circuit board, battery, and LEDs in a small box as shown in **Photo 7**. The DS18B20 is in the lid just left of center, and the yellow and orange wires go to an externally mounted mode button. You will also note that the positive lead from the circuit board goes directly to the metal case as do the anodes from the six LEDs. This simplifies wiring as the only leads that come back from the LEDs to the circuit board are those from the cathodes. The SPDT toggle switch turns the unit on and off. When the switch is off, the rechargeable battery connects to a charging plug (hidden from view in the photo) so that you cannot inadvertently apply charging voltage to the circuit.

Enhancements

The next revision of the circuit board will control each of the two MOSFETs with a separate pin on the PIC. This will allow independent control of the front and back LEDs. This would allow a mode, for example, that would leave the back red LEDs flashing while the front white LEDs could be on constantly so that you could read a map or perform repairs. I'm sure that additional modes of operation will come to mind, as well.

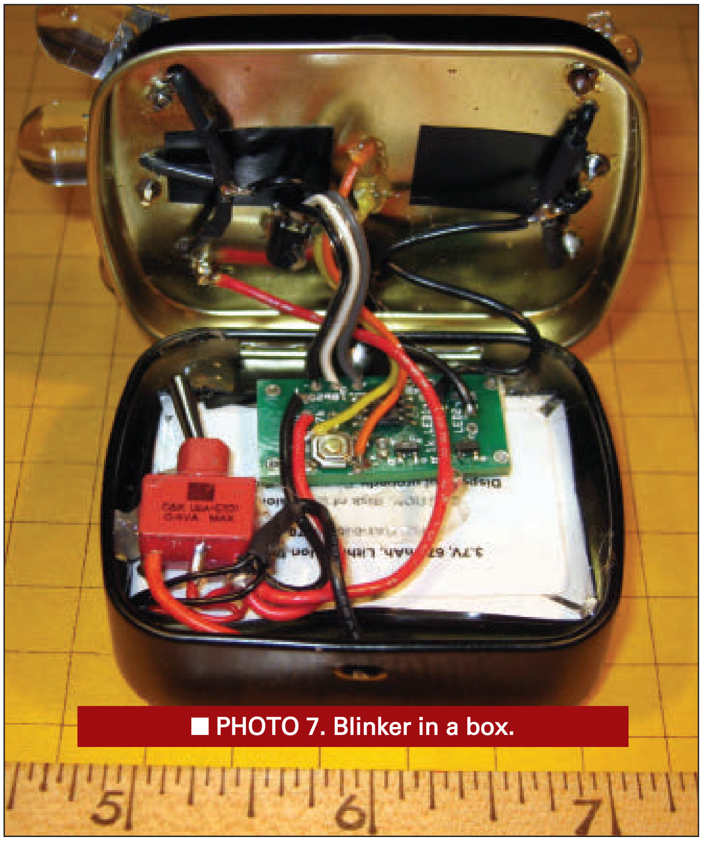
I am also considering — at the request of a non-cycling friend — making a solar powered unit with only one LED. It will be placed in his garden to continuously report the outdoor temperature. He reasons that it will give a better outside reading that a thermometer close to the house and he will be able to read it without putting on his glasses!

Conclusion

I have made a number of Bike Blinker +Plus+ units for personal use and for friends. I encourage you to do the same. I think you will find that it can add to your visibility and may provide some fun, as well.

Try this: Leave your helmet flashing on the bike when you go into the local coffee shop. Invariably, someone will tell you that you forgot to turn the light off. Watching their reaction as you relate how it is giving you temperature reports is an added benefit that is sure to make you smile! **NV**

A complete kit to go with this article can be purchased online from the *Nuts & Volts* Webstore at www.nutsvolts.com or call our order desk at 800-783-4624.



■ PHOTO 7. Blinker in a box.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PCB Holder with Magnifying Glass
TH-1983 $6.50 plus postage & packing
Any time you need that extra bit of help with your PCB assembly, this pair of helping hands will get you out of trouble. With a 90mm magnifying glass, it also provides an extra pair of eyes. Great for model builders and other hobbyists.
• Dimensions 78(L) x 98(W) x 145(H)mm
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TH-1812 $17.50 plus postage & packing
Set of five 115mm cutters and pliers for electronics, hobbies, beading or other crafts. Stainless steel with soft ergonomic grips.
Contents:
• Flush cutters
• Long nose pliers
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• Bent nose pliers
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SD/MMC CARD WEBSERVER IN A BOX
KC-5489 $52.25 plus postage & packing
Host your own website on a common SD/MMC card with this compact Web server In a Box (WIB). Connecting to the Internet via your modem/router, it features inbuilt HTTP server, FTP server, SMTP email client, dynamic DNS client, RS232 serial port, four digital outputs and four analog inputs. Requires a SD memory card, some SMD soldering and a 6-9VDC adaptor. Kit includes PCB, case and electronic components.
• PCB: 123 x 74mm
"MINIVOX" VOICE OPERATED RELAY
KC-5172 $9.50 plus postage & packing
Voice operated relays are used for 'hands free' radio communications and some PA applications etc. Instead of pushing a button, this device is activated by the sound of a voice. This tiny kit fits in the tightest spaces and has almost no turn-on delay. 12VDC @ 35mA required. Kit is supplied with PCB electret mic, and all specified components.
• PCB: 47 x 44mm
RADIO KITS
SC2 Project - FM Radio with Electronic Tuning
KJ-8238 $20.50 plus postage & packing
This is a true state-of-the-art 88-108MHz FM radio with electronic station tuning and powerful amplifier included! It has a voltage regulated power supply and works really well. Your friends won't believe you built it. PCB and all board parts supplied. Requires 9V battery.
Instructions NOT included. See KJ-8239 $1.25 for individual instructions or full color project book BJ-8504 $6.50
• PCB: 108 x 51mm
Three Stage FM Transmitter
KJ-8750 $14.00 plus postage & packing
This is a three-stage radio transmitter that is so stable you could use it as your personal radio station and broadcast all over your house. Great for experiments in audio transmission. Includes a microphone, PCB with overlay and all electronic components.
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• Requires 9V battery
• Broadcasts up to 800m
• PCB: 70 x 17mm
Crystal Radio Kit
KV-3540 $7.75 plus postage & packing
Enjoy AM broadcasting without using battery or other power sources. Ideal for entry-level students or hobbyist with little electronics experience. Includes circuit explanation. Kit supplied with silk-screened PCB, crystal, prewound coil, earphone and all components.
• PCB measures: 81 x 53mm
SC3 Project - Mini-mitter FM Transmitter
KJ-8114 $14.00 plus postage & packing
Transmit stereo audio from your tape deck or CD player to any FM radio elsewhere in your house. You could even tune in on a portable walkabout radio.
• Kit supplied with PCB, 1 x AA battery and electronic components.
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See KJ-8115 $1.25 for individual instructions or full colour project book BJ-8505 $7.50.
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• PCB measures: 141 x 101mm
Jaycar Electronics and Silicon Chip Magazine will not accept responsibility for the operation of this device, its related software, or its potential to be used for unlawful purposes.
USB Experimenter's Interface Kit
KV-3600 $40.75 plus postage & packing
Interface your computer to the real world. There are five digital and two variable gain analog inputs. Eight digital and two analog outputs are available. Supplied with all components, silk screened PCB, assembly manual, and software. See website for full specifications.
• PCB measures 145 x 87mm
PC Controlled Stepping Motor
KV-3594 $29.00 plus postage & packing
This kit will enable you to control the supplied stepper motor manually, or via your computer's parallel port with the software provided. You can accurately control the motors direction, speed and number of rotations. This kit has many uses and is only limited by your imagination. Use it to experiment in robotics, for camera panning, a radio antenna rotator or even to open the curtains in the morning. Kit supplied with PCB, stepper motor, software and all electronic components. Computer cable required WC-7502 $7.00
• PCB: 92 x 68mm
PC Link for Automatic Control
KV-3590 $40.75 plus postage & packing
Automate your household appliances, switch on garden lighting, turn on sprinklers or even control your household heating with this terrific kit. Each SPDT relay can handle 10 amps and has an LED to show whether it is on or off. Software is provided on a 3.5 disk. Kit includes PCB, relays, software, and all electronic components. 8 - 12VDC power required (use plugpack MP-3008 $10.00).
• PCB: 185 x 90mm
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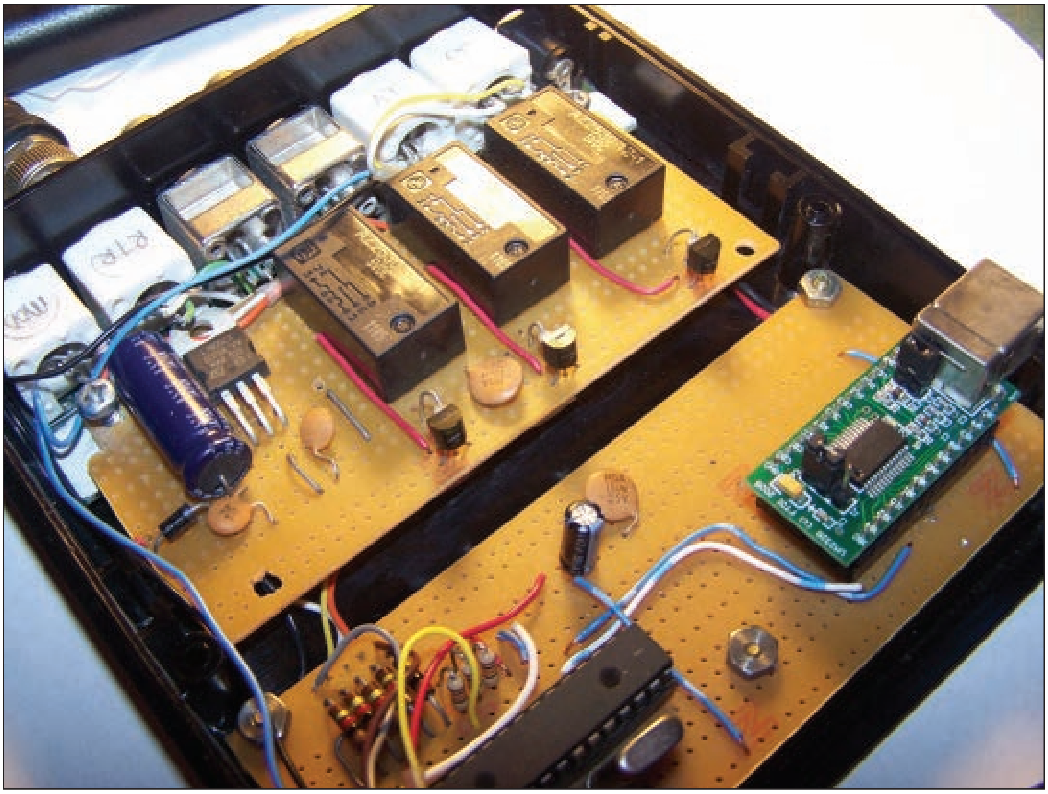
By Jim Sky

BUILD THE WATCHPUPPY

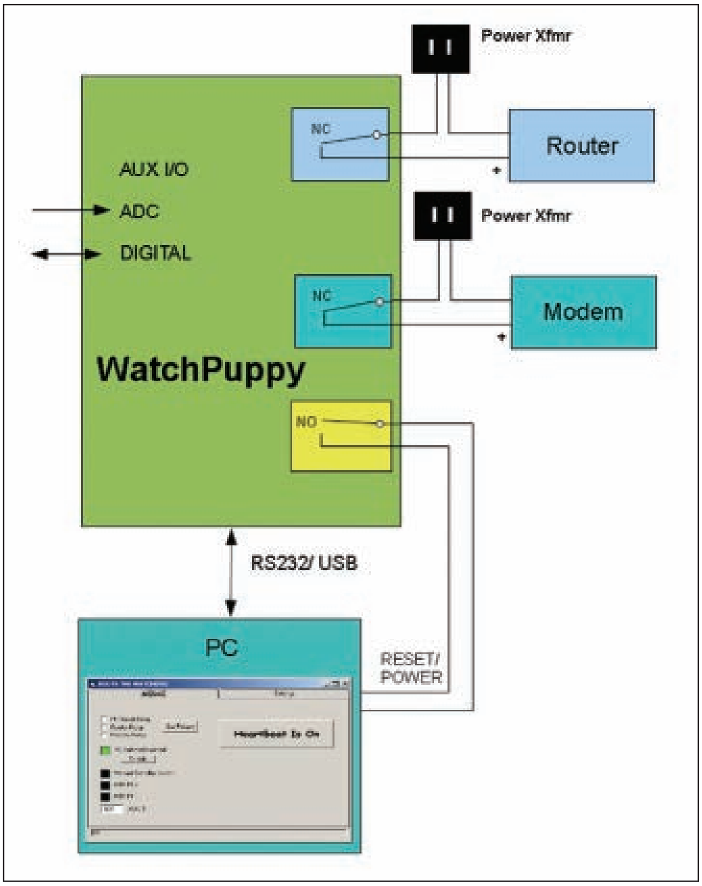


For several years now, I have remotely managed a small radio observatory at a school campus in Hawaii. There are a number of PCs that run the radiotelescope receivers and make the data available online. When the project began, it seemed like we constantly had to call someone at the school and have them go over and reboot one or more of the PCs. Things are better now that Windows XP has matured. Still, there is the occasional problem that requires a person to manually push the power-reset button. This project is aimed at replacing that human button pusher with a bit of automation.

If you work with microcontrollers, you are probably aware that many of these chips have internal "watchdog timers." These consist basically of a virtual reset button connected to a timer. If the watchdog timer is not reset before a set time expires, the microcontroller reboots itself. This can be helpful if by some chance the device gets stuck in a loop waiting for an external stimulus that never arrives. Watchdogs are also available for larger computers. These devices may take the form of an internal card or external device that monitors the PC for a regular signal. If the signal fails to arrive within a predefined time, it is assumed that things are awry in either software or hardware, and a hardware reset is applied to the PC. Often this reboot fixes the problem.

While there are commercially produced PC watchdogs in the $100-$400 range, I decided to build my own for less than $50. I wanted to incorporate non-standard features into my PC watchdog: the ability to reboot my modem and router in case of Internet loss; the ability to monitor a voltage; and the ability to monitor digital inputs from other equipment. (This extra I/O would allow me to remotely log into my PC and monitor other equipment.) I dubbed this little project the WatchPuppy. It is intended for use with desktop computers.

The WatchPuppy consists of two major components: the PIC controller based device that activates the reset relays and a program running on the PC that sends a



■ FIGURE 1. Diagram of the WatchPuppy system. Software on the PC alerts the device that the PC is running okay and prevents the board from rebooting the computer. The black boxes are wall-wart supplies for the router and modem.

heartbeat to the PIC to let it know that the PC is functioning properly. In this article, I will refer to the hardware part as the *WatchPuppy* and the PC side software will be the *WatchPuppy Monitor*. In our case, the heartbeat is sent via a USB connection and a UM232R USB-to-serial adapter but a standard comport will work just as well by substituting a MAX232 or similar level shifter.

The WatchPuppy is based on a PIC16F873. It may be overkill to use the 16F873, as many of the I/O lines are not necessary in this application. This type of project would also be well served by a PICAXE or other BASIC based device. (Of course, in that case you will have to write the software yourself, but that's part of the fun right?) My code is written in assembly language and is available at **www.nutsvolts.com**.

The PIC program uses a TMR1 interrupt routine to keep time. The interrupt is set to fire every 100 ms and its service routine keeps track of seconds using a counter. There is also a counter that tracks minutes. The interrupt routine flashes the status LED on RB7. A rapid flash indicates the PIC has been placed in a standby mode by a command from the PC. A slower flash tells you that the device is actively monitoring the status of the PC by listening for "heartbeats" on the USB/RS-232 line.

When not in the interrupt routine, the PIC is looping through code that checks for serial commands arriving from the PC. It also checks the status of the manual standby switch S1, and monitors BootCount — a counter that increments each minute in the TMR1 interrupt routine. If the WatchPuppy has not been disabled by command or the manual standby switch, a PC reboot is initiated when BootCount reaches the configurable value, BOOT. Every time a command is received from the PC, BootCount is reset to zero thus delaying the reboot operation. Requests from the WatchPuppy Monitor for the status of the PIC provide the heartbeat signal that lets the WatchPuppy know that the PC is still alive.

The WatchPuppy uses a watchdog of its own! I have enabled the PIC16F873's internal watchdog timer in the configuration fuses. I set this internal watchdog to the maximum value of 2.3 seconds. If a command to clear the watchdog timer (**clrwdt**) is not issued for 2.3 seconds, the PIC will reset itself. This might get us out of a jam where there was a glitch in the communications with the PC and

PARTS LIST

ITEM	DESCRIPTION	SUPPLIER/PART #
U1	PIC16F873-20/P	**Mouser.com** 579-PIC16F873-20SP
U2	UM232R USB-to-serial converter	Mouser 895-UM232R
U3	LM7805 voltage regulator	Mouser 512-LM7805CT
Y1	4.000 MHz crystal	Mouser 559-FOX040-LF
C1, C2	22 pf 50V disk ceramic capacitor	**Allelectronics.com** #220D50
C3, C3	0.1 MF 50V ceramic capacitor	All Electronics #RM-1045
R1, R2, R5, R8, R9, R10	1K 1/4 W	All Electronics #291-1K
R3, R4, R7	10K 1/4 W	All Electronics #291-10K
D1, D2, D3	1N4001	All Electronics #1N4001 or similar rectifier diode
D5, D6	T 1 3/4 Red LED	All Electronics #LED-1
Q1,Q2,Q3	2N2222 NPN transistor	All Electronics #2N2222A
K1,K2,K3	5V Coil DPDT relay	Takamisawa # NA5W-K; All Electronics #RLY-538

Misc.
Terminal Strip for external connections.
Power Supply Wall-wart type 9-12 VDC, one amp

the PIC is waiting for a character to arrive that never does.

Rebooting Hardware Connections

Tapping into the computer power or reset switch is a necessary part of implementing the WatchPuppy. Don't do anything inside your PC with the power on. Be very careful when moving connectors; it's easy to place one on the wrong pins. Try to find your motherboard documentation. You are looking for the motherboard jumper and connector diagrams, and any descriptions of the boot options.

The WatchPuppy reboots the PC by closing a relay attached to the motherboards *reset line* or *power button connection*. It seems that the reset button that was so common on the fronts of so many old AT style computers is a rare animal these days. More often, we now see only a power button on the PC. A reset connection may still be available on the motherboard, so check your documentation. If a reset line is available, you simply have to short the conductors together for a second or two to reboot the PC.

Some computers may not have a reset button available on the case but may have a pair of reset pins available on the motherboard. Labeling on the board may be very cryptic or non-existent. A reset button will be terminated in a small black two-conductor in-line

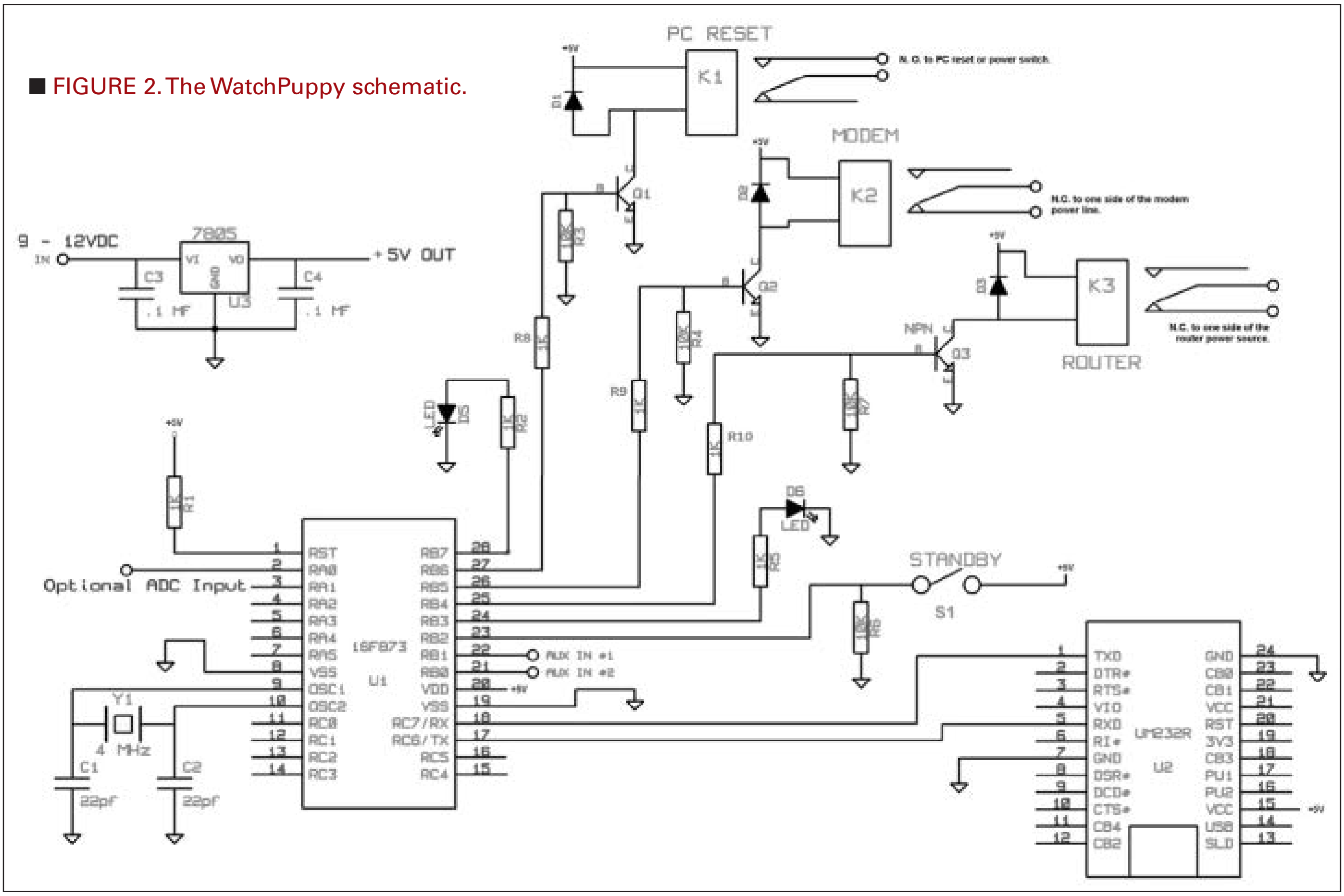
■ FIGURE 3. Typical reset switch connector that attaches the switch to the motherboard header pins.

connector. This will probably be labeled RESET SW, RESW, or something similar. Unfortunately, there is no standard color code for the wires running to the reset or power buttons.

Our other option is to use the power button. For the power button to be effective in rebooting the computer, it must be of the type that will force a hard shutdown after being pressed for a given amount of time. Actually, it is the motherboard BIOS that does this. The button is just a momentary contact switch with no smarts. Measure the length of time you need to press the switch before the computer shuts off. You will need to know this in order to set the relay pulse width to accomplish this task. Before running this test, close any applications.

Note that when I refer to "power button" here, I do not mean a power switch that directly interrupts the line voltage going to the power supply! If you only have this kind of power switch on your PC case, you are dealing

■ FIGURE 2. The WatchPuppy schematic.

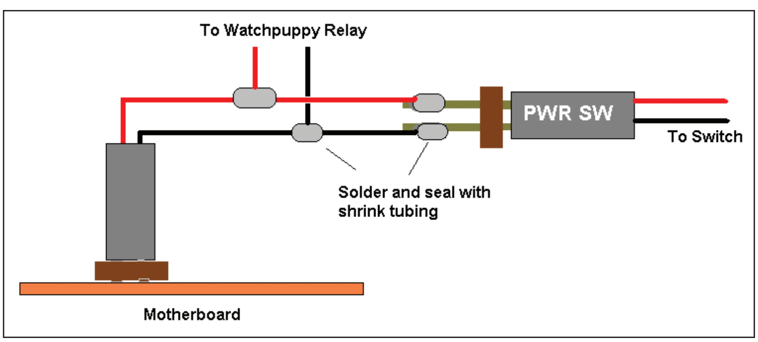


■ FIGURE 4. Headers like this one appear on most desktop motherboards. This one has power button (PWBT) and reset (RST) positions.

with some very old technology and should not use the WatchPuppy to manage it. You could electrocute yourself playing with that type of switch. Here, I refer to the type of low voltage power switch that connects via two small wires to a pair of pins on the motherboard. The power connector will be labeled with PWR SW, PWBT, POWER, or something similar.

I fashioned a jumper to connect the WatchPuppy to the motherboard from a pair of male header pins and a matching female connector from an old PC. This avoids hacking into the computer wiring directly and makes it easier to move the WatchPuppy to another PC. Adding a plastic grommet to a hole drilled in a peripheral card slot cover makes a clean way for the wire to the reboot relay to exit the PC case.

With either the reset or power switch, we are placing a set of relay contacts in parallel with the manual switch. The length of time the relays will remain closed is configurable and saved in the WatchPuppy's EEPROM. In the case of the power switch, you will also configure a pause and a second relay closure that will turn the PC back on. A reset operation does not require this second pulse.



■ FIGURE 5. You can make a removable connection for the reboot relay. Cover the bare connections with heat shrink tubing or liquid tape.

Construction

I built my WatchPuppy in a recycled plastic case on a RadioShack IC breadboard. I separated the boards for the relays and the PIC, but this is not mandatory. The front panel (not shown) consists of two small LEDs and a single switch that is used for manually disabling the reboot function. The status indicator LED shows whether or not the WatchPuppy has been disabled in software. The other LED is illuminated whenever there is a PC reboot operation in progress. The box I used had a row of fully insulated BNC connectors on the back so I used them for external connections. However, a much simpler solution would be to use a screw-down terminal block of your choosing.

The WatchPuppy gets its power from a filtered nine to 12 VDC, one amp, wall-wart type power supply. This voltage is reduced on the WatchPuppy board by an ordinary LM7805 voltage regulator. The heft of this regulator insures we have plenty of current to power the three five volt relays. You may note that the relays I used are not the ones listed in the **Parts List**. My source for the AZ2530-12-1 relays has disappeared but there are many other 5V coil relays that will work. Try to find relays that close with coil currents of about 100 milliamps or less. General-purpose NPN transistors capable of bearing the relay coil currents are used between the PIC outputs and the relays. Protection diodes are used across the relay coils to guard against transients produced by the coils.

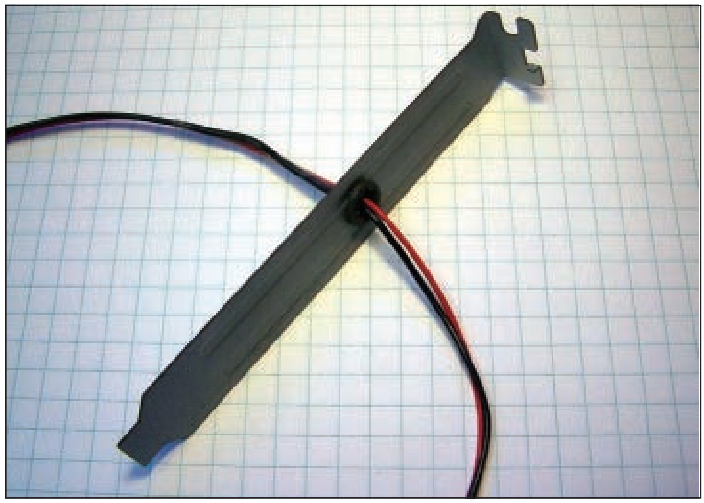
The UM232R must be jumpered to take its power from the same supply as the PIC and not from the USB bus. This equates to removing jumper 2. I tried using the USB bus to power just the UM232R but when the PIC board power supply was unplugged, the PIC still ran! Enough voltage fed back through the TX and RX pins from the UM232R to power the PIC, albeit in a rather unstable fashion. (You learn something with every project.)

The ADC input and two digital inputs may be expanded by modifying the PIC and PC code. My plan for the ADC is to monitor temperature. This can be done with a thermistor in a voltage divider configuration or with any of a number of temperature sensor devices. The digital inputs can be used to monitor other devices to see if they were operational. These and other pins could also be configured as outputs to control other things, including more relays.

Modem/Router Rebooting

If you have ever lost Internet service and had to call your DSL or cable-based ISP tech support, you

no doubt have been told to reboot the DSL/cable modem and/or the router by unplugging the power supply. The WatchPuppy uses this same crude reboot method to try to restore Internet service. These devices are almost always powered by low voltage wall-wart type transformers. You will have to break the positive side of the two-wire conductor to the transformer. Extend this break with two wires to the WatchPuppy relay connections. You will use the normally closed (NC) relay contacts. The router and modem will then remain powered on even when the WatchPuppy is itself not powered. If you do not want to cut the wires leading to the transformers (they might belong to someone else after all), you could create jumpers with the appropriate male and female connectors that would allow non-destructive insertion of the relay contacts into the power cord.



■ FIGURE 6. A clean exit from the PC case is achieved by modifying a slot cover.

The PC Side of Things

The WatchPuppy Monitor has several purposes. In addition to providing the PC heartbeat, it also monitors the Internet connection and issues the commands to the WatchPuppy to reboot the modem and/or router. The program manages the WatchPuppy configuration including the options and timing parameters that are saved in the WatchPuppy device EEPROM. Lastly, the program is the place you would display the status of any auxiliary inputs — digital or analog.

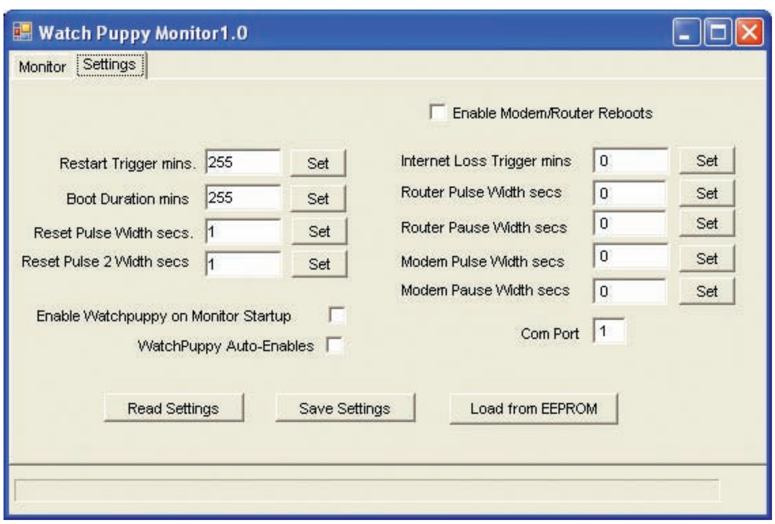
Microsoft provides VB.NET 2008 Express Edition for free. I wanted you to be able to make modifications, so I decided to translate the code from VB6 to the VB.NET language. You can get VB.NET 2008 at **www.microsoft.com/express/vb/Default.aspx**.

The source code and executable are provided at my website at **http://radiosky.com/WatchPuppy/**. The executable is provided if you are okay with using the program as-is. I encourage you, however, to look at your own specific remote management needs and experiment with ways to improve usefulness and reliability. Possible improvements include re-labeling the auxiliary inputs for specific uses and translating the ADC input to units meaningful to your purpose. Also, a simple logging facility might be useful so that you can see when problems have arisen in your absence. You might add a routine that has the program email you or send you a text message saying everything is okay once a day. The possibilities go on and on.

The monitor program relies on a software timer to call the routines that read the status of the WatchPuppy every five seconds. If the modem/router reboots are enabled, the WatchPuppy Monitor will also check the online status of the computer. After the time (in minutes) specified in the Internet Loss Trigger has expired without a successful test, the modem and/or router will be rebooted.

Within the monitor program, you will want to configure the action of the boot relay to correspond with the reboot method that you implement on the computer (reset or power button). Click the **Settings** tab and note the top four entries on the left. **Restart Trigger** is the length of time in minutes that the WatchPuppy will wait without hearing a heartbeat before it begins the reboot. **Boot Duration** is the length of time that you expect a PC reboot to take. After this amount of time, the WatchPuppy will again start listening for heartbeats. If the reboot is accomplished sooner, the reception of a 'W' status request from the PC will end this wait period. The **Reset Pulse Width** is usually several seconds for the power switch. Physically test this parameter. If you are using a reset switch and do not need the second pulse of the switch to restart the computer, then place zero in the **Reset Pulse 2 Width** textbox.

There is a global enable for the modem/router



■ FIGURE 7. Settings screen of the WatchPuppy Monitor program. PC reboot parameters are on the left; modem/router reboot parameters are on the right.

reboots. In addition to the power-off pulse durations for these devices, there are also pause parameters. The modem is rebooted first (if it is set with a pulse width greater than zero), and then the router is reset. You may need to experiment with these modem/router reboots to determine the pause times. Triple these values before applying it to your settings. We are trying to avoid getting into any kind of vicious cycle.

Settings may be changed at any time but you should first place the WatchPuppy in *PC Reboot Disabled* state (see under the **Monitor** tab) and also temporarily stop the heartbeat by pressing the ***Heartbeat is On*** button to toggle it off. Now, click on the **Settings** tab, type in your values, and click the associated **Set** button with each box you change. Save settings permanently by clicking the **Save Settings** button, and then go back to the **Monitor** tab, restart the heartbeat, and re-enable the WatchPuppy.

Other PC Considerations

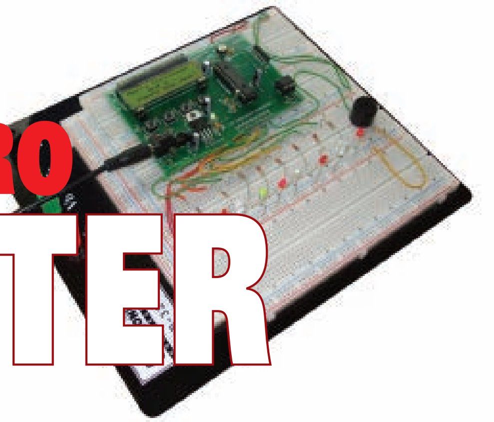
An ever-present problem is that you might lose AC power at your unattended site. When this happens, the WatchPuppy will not be much help if it powers up in a disabled state. You may set the WatchPuppy so that it will power up in either an enabled or disabled state but if you choose the enabled option, you will have to take greater care to not accidentally reboot while the unit is not being used.

Set the PC motherboard BIOS to boot the operating system after a power loss. This option is available on most computers. After power is restored to the computer, it will automatically turn on and load the OS and the WatchPuppy monitor program. If you set the WatchPuppy Monitor program to *Enable WatchPuppy Device on Start Up,* then all should be well after the power loss.

If you are using a UPS and use controlled shutdown software, then you should use the power button rather than a reset switch to reboot the PC. Some UPS systems can programmatically shut down the operating system after the battery backup power drops to some low level. A reset switch cannot turn the PC back on. The power switch, however, can restart the PC. If you must use a reset switch, you can elect *not* to use the UPS gentle shutdown software. The BIOS option that reboots on power loss may then be used to restart your computer. **NV**

See **http://radiosky.com/WatchPuppy/unattended.html** for additional suggestions on how to achieve a clean reboot and to do remote administration.

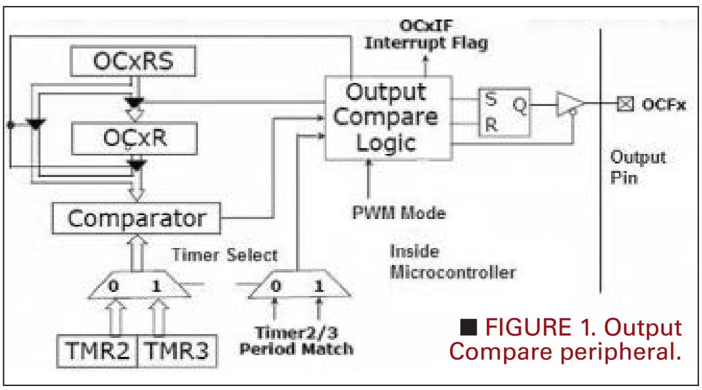
BY THOMAS KIBALO



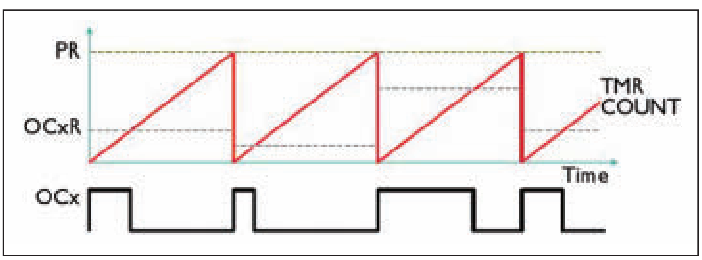
PULSE OPERATIONS WITH THE 16-BIT MICRO EXPERIMENTER

In this article, we will look at the digital pulse capture and generation capabilities of the 16-bit Micro Experimenter (Experimenter for short). Pulse operations are important for a large variety of microcontroller applications, and with the Experimenter's PIC24F we have an impressive arsenal of internal modules: a total of five Input Capture modules and five Output Compare modules. The Input Capture modules can capture pulse edges to measure pulse frequency and pulse width. The Output Capture modules can generate pulse waveforms with a changeable duty cycle on output. In both cases, minimal software is required to operate these modules, as a lot of what they do is done in hardware.

We will cover the use of these modules in a series of five demos to include: LED brightness control; servo control; DC motor speed and direction control; reading an accelerometer; and range finding. Some of these apps may be familiar to you, but here is an opportunity to apply 16-bit horsepower and get collection of C drivers to boot! There is lot of ground to cover, but it is definitely worth it to be able to understand and use this pulse capability. As stated in earlier articles, all software will be kept to general level straightforward functional calls, however, some basic familiarity with C language syntax will be required. Let's start with the Output Compare module first and review the basics of this peripheral.



■ FIGURE 1. Output Compare peripheral.



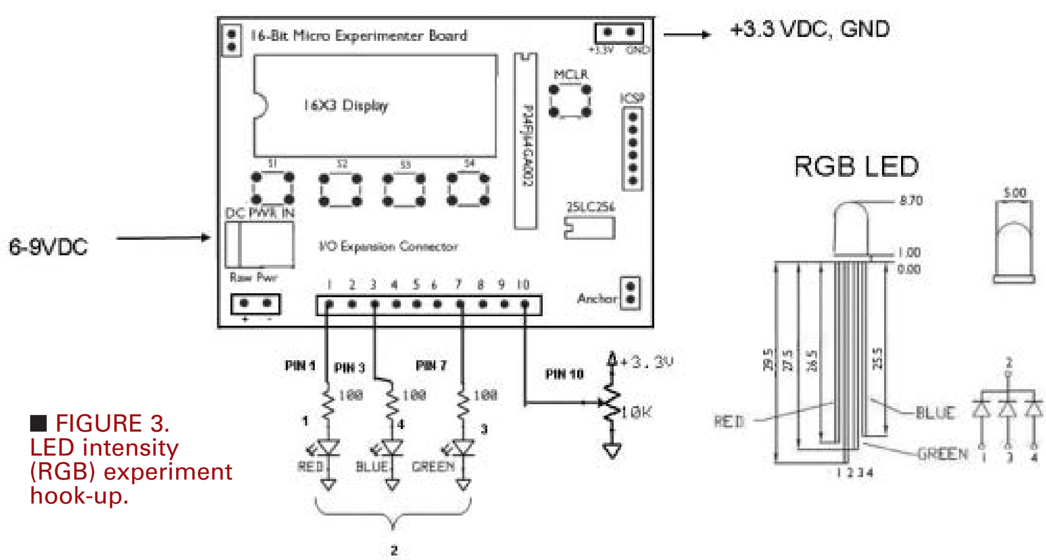
■ FIGURE 2. Output Compare pulse generation.

Output Compare Module

The PIC24FJ64GA002 (used in the Experimenter) has five Output Compare modules (OCX; where X = 1, 2, 3, 4, 5). Any OCX can be mapped to a number of the pins of the Experimenter's 10 pin I/O Expansion Bus. A block diagram of an OCX is shown in **Figure 1**.

The OCX module can use either the PIC24FJ64GA002 16-bit timer 2 (TMR2) or timer 3 (TMR3) as a time base, and the period setting for the output pulse waveform. PR2 is the period setting for timer 2 and PR3 is the period setting for timer 3. The OCXRS and OCXR registers are loaded with a 16-bit value to control the width of the pulse generated during the output period. This value is compared against the timer during each period cycle. The OCX output starts high and then when a match occurs, OCX logic will generate a low on output. This will be repeated on a cycle by cycle basis (see **Figure 2**). For our demos, we use the OCX in Pulse Width Modulation (PWM) mode. PWM is a very powerful technique and is used in a variety of applications. An important notion in thinking about PWM is that it allows dynamic changing of the DC voltage level to a load. Wait a minute, you say — where's the DC voltage here? Think of the DC voltage as

the average voltage value of the pulse DC across the waveform period. For example, if we have the pulse high for 50% of the period consistently and the pulses are +3.3V, then we are supplying (on the average) 50% of 3.3V to the load or 1.65V. In order to change the pulse width while the system is running, we simply write into OCXRS and it automatically loads into OCXR on the next cycle.



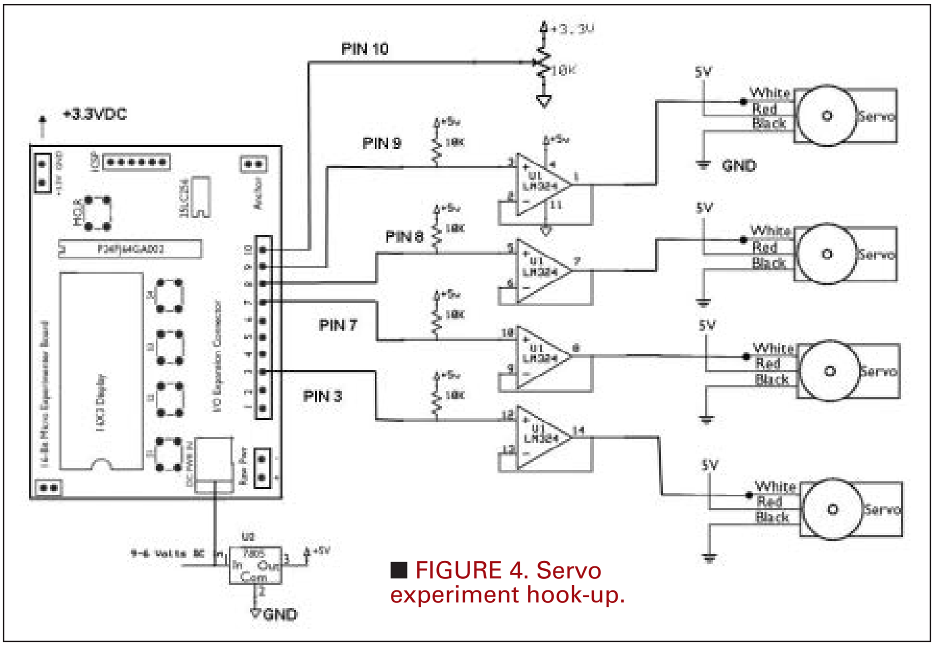
■ FIGURE 3. LED intensity (RGB) experiment hook-up.

We'll look at how to apply this idea in the following applications (all hardware hook-ups and source code is provided at **www.nutsvolts.com**).

Demo 1. RGB LED color control using PWM
- Using changing PWM to control DC level to an LED, thereby controlling its brightness and (in the case of RGB) its color.

Demo 2. Running four R/C servos simultaneously
- This simply provides a 1.5 msec to 2 msec pulse width over a 50 Hz period to control servo position.

Demo 3. Independent dual motor controls
- This allows for two DC motors to be independently controlled in both speed and direction.



■ FIGURE 4. Servo experiment hook-up.

RGB PWM Experiment

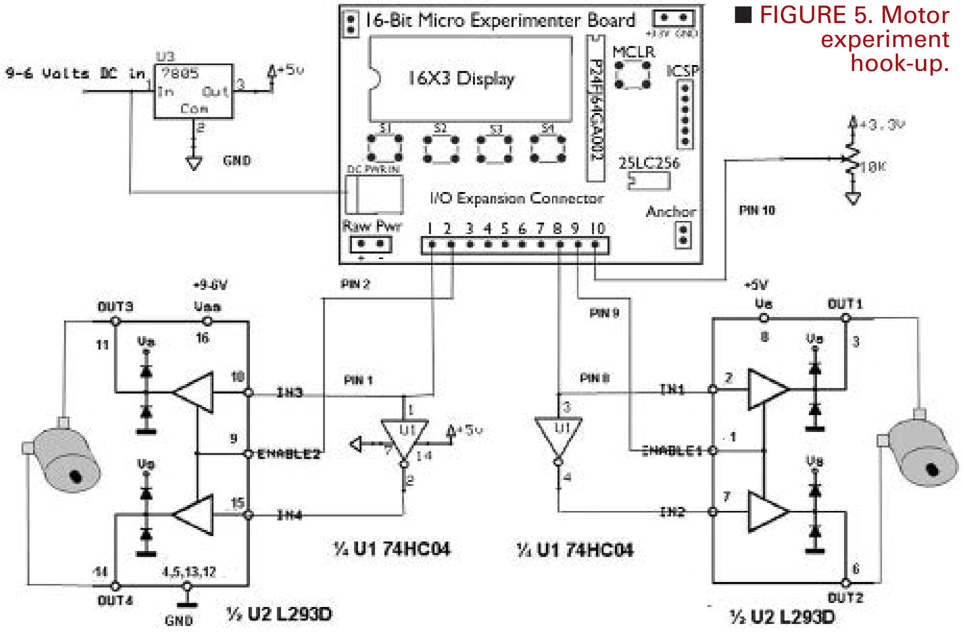
In the original introductory demo code for the Experimenter, we had an RGB demo. This is a similar exercise with a little more focus on the software and hardware elements. This experiment uses three of the five OCX modules — OC1, OC2, and OC3 — to independently drive each LED (red, green, and blue) that is put together in a single RGB LED package. With PWM on each of the LEDs, we can control the individual light intensity for each one to realize up to 16M colors. The code is contained in RGBDEMO, and the hook-up is shown is **Figure 3**. There are several key C functions:

- **Initialize PWM ()** - OC1, OC2, OC3 for PWM operation using TMR2 as common timing source.
- **ColorRed_on (), ColorRed_off(),ColorGreen_on (), ColorGreen_off(),ColorBlue_on (), ColorBlue_off()** — individual functions per LED type for on or off.
- **Set_ColorRed (setting), Set_ColorGreen (setting), Set_ColorBlue (setting)** — Sets the PWM duty cycle of the designated color red, green, blue, thereby changing combined color. Designated color (or LED) is selected via pushbutton by user. Current LED is stored as a number 1 to 3 in variable sel_color.

We use the LCD and pushbutton C libraries for the display and selection of the LED. We use the ADC library to digitalize the pot value connected to pin 10 to get the brightness value (see earlier 16-bit Experimenter articles for explanation on these C libraries and their appropriate functions).

Servos Experiment

This experiment uses OC1, OC2, OC3, and OC4 to generate pulse modulated waveforms to independently



■ FIGURE 5. Motor experiment hook-up.

timer 2 periods for 100 Hz.

As you turn the pot, the pulse width changes linearly from 1 msec to 2 msec in accordance with the required servo control pulse format (see **Figure 6**). A hook-up diagram is supplied (**Figure 4**).

Plug your Experimenter into a solderless breadboard and then add all the necessary components. Note that a 14-pin DIP LM324 quad op-amp and a 7805 three terminal +5V regulator is used in the circuit along with four 10K resistors and a 10K pot. The additional electronics are necessary because the Experimenter is a +3.3V system and each servo's power and pulse control needs to be five volts. To accomplish this in software, each OCX output is configured as an open drain, and a 10K pull-up resistor to +5V is tied to each output. This trick converts each of these normal +3.3V outputs to a 5V level. Each LM324 op-amp is configured as a unity gain follower for each of these OCX outputs to drive the servos. The project code file is SERVODEMO.MCP. Open this project, build it, and download it into the Experimenter using a PICKIT2 programmer.

Important software functions (notice the similarity with the RGB example) are:

- **servo_init ()** — Initializes OC1, OC2, OC3, OC4 for PWM operation using timer 2 as the common timing source. All the OCx are enabled for 1.5 msec or center position of the servos.
- **Servo1_on (), Servo1_off(), Servo2_on (), Servo2_off(), Servo3_on (), Servo3_off(), Servo4_on (), Servo4_off()** — individual functions per servo to turn them on or off.
- **Set_Servo1 (setting), Set_Servo2 (setting), Set_Servo3 (setting), Set_Servo4 (setting)** — Sets the PWM duty cycle of the designated servo. Designated servo is selected via pushbutton by user. Current selected servo is stored as number 1 to 4 in variable sel_servo.

This experiment can work with a reduced number of servos, as well. Again, we used the LCD, ADC, and pushbutton C libraries.

Please review the PWM profile (**Figure 6**) to understand PWM requirements for servo control.

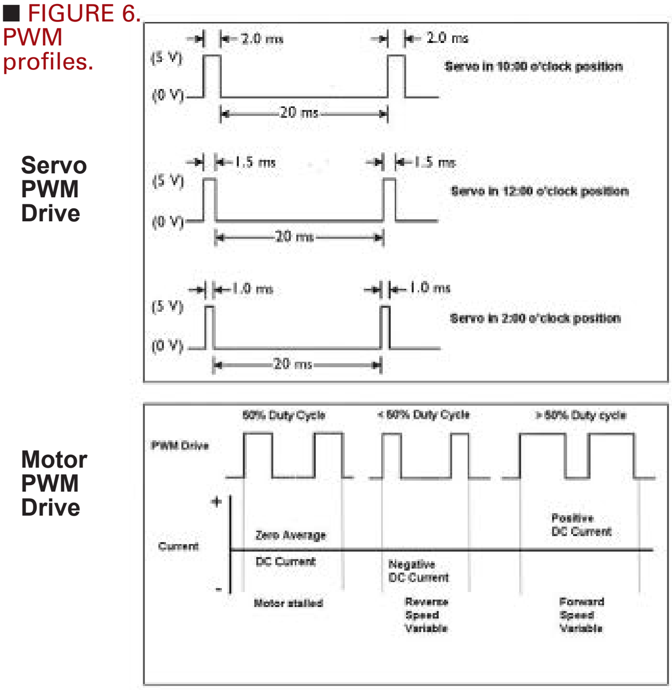
Motor Control

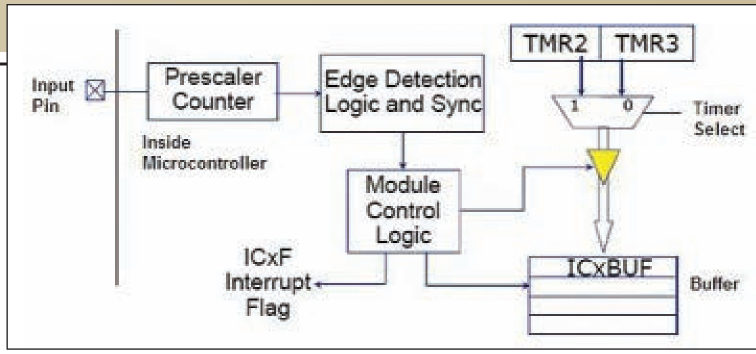
No PWM discussion is complete without considering motor control. In this experiment, we will be

drive four servos. The Experimenter can drive up to five servos but the demo uses only four (since it fit nicely with the use of the four pushbuttons for servo selection). To select a servo, use a pushbutton (SW1 = servo1; SW2 = servo2; SW3 = servo3; SW4 = servo4). The selected servo and its current setting are displayed on the Experimenter LCD.

To change the selected servo positions, just turn the potentiometer. Turning pot CWW adjusts the servo position to the left. Turning pot CW adjusts the servo position to the right. The servo is slaved to the potentiometer position. The pot value (pin 10 of the Experimenter I/O expansion bus) is digitized by the PIC24F ADC and this value is used to set the OCXR register of the OCX to drive the selected servo. The code sets up the

■ FIGURE 6. PWM profiles.





■ FIGURE 7. Input Compare peripheral.

independently controlling both speed and direction of the motors using OC1, OC2, and using two half H-bridges. The bridge package we are using is the 16-pin DIP L913D; this supplies two half bridges (one for each motor). Again, we need a +5V system, so we use a three terminal 7805 +5V regulator. One other piece of electronics is a 14-pin DIP 74HC04 quad NOR gate (however, any logic inverter will do) for driving dual pulse inputs (positive and negative polarities) to each half bridge. Finally, again we have our 10K pot for the actual control settings. Note because the Experimenter +3.3 OCX outputs are TTL compatible, there is no need for pull-ups. Hook-up connections are shown in **Figure 5**. The bridge runs off +5V for logic but the motor voltage has to be higher than this (we are using +6 DC available as input value to the 7805 regulator). Note the similarities with the previous servo experiment:

- **motor_init ()** — Initializes OC1, OC2 for PWM operation using TMR2 as the common timing source. All the OCx are enabled for 50% duty cycle — causing both motors to stall.
- **Motor1_on (), Motor1_off(), Motor2_on (), Motor2_off()** — Individual functions per motor to turn them on or off.
- **Set Motor1 (setting)**, **Set Motor2 (setting)** — Sets the PWM duty cycle of the designated motor. Designated motor is selected via pushbutton by user. Current selected servo is stored as number 1 to 2 in variable selmotor. If PWM is less than 50% duty cycle, then the motor is in the reverse direction with variable speed; if duty cycle is more the 50%, motor is in the forward direction with variable speed. If duty cycle is 50%, motor is stalled and not moving.

We are using the LCD, ADC, and pushbutton C libraries again from earlier 16-bit Experimenter articles. The code is contained in MOTORDEMO.

Please review the PWM profile (**Figure 6**) to understand the PWM requirements for motor control.

Input Compare Module (ICX)

As we mentioned earlier, the PIC24FJ64GA002 has five Input Compare modules. Any of the five Input Compare module ICX (X can represent any number from 1 to 5 for our processor) can be mapped to a number of pins on the Experimenter's 10-pin I/O expansion bus. A block diagram of the ICX is shown in **Figure 7**. The ICX uses designated external level conditions to capture a free running 16-bit timing source. This becomes the basis for pulse level measurement. The ICX can measure the width of the pulse by capturing each leading and trailing edge and subtracting the time differences from both edges.

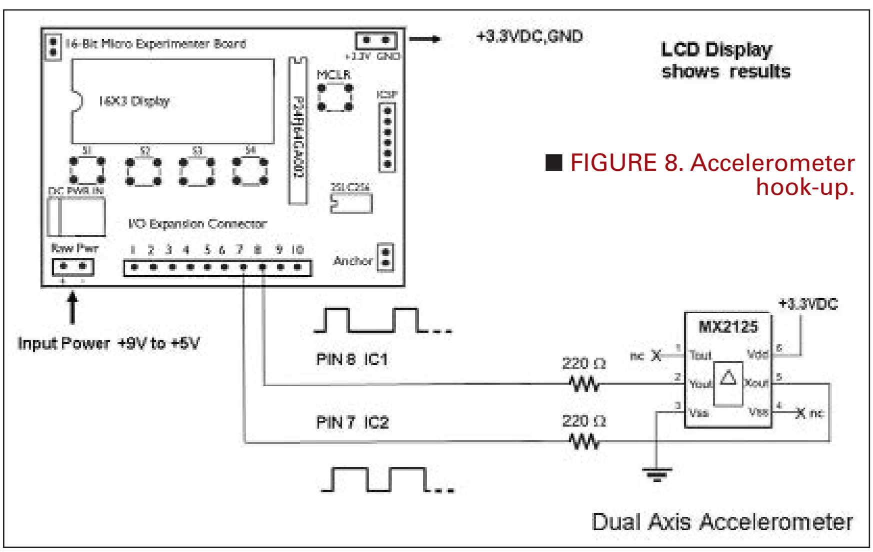
Again, as in the OCX, most ICX activities occur in the hardware of the peripheral (software is minimal). It can be configured with either timer 2 or timer 3 as a free running time base. Edge captures are automatically loaded into a buffer (ICXBUF). We will look at the ICX operations and work through the following applications (hardware hook-ups and source code are provided):

Demo 4. Measuring the pulse output from a two-axis accelerometer (changing duty cycle is proportional to changes in sensor acceleration).

Demo 5. Measuring the pulse output (range data) from an acoustic range finder.

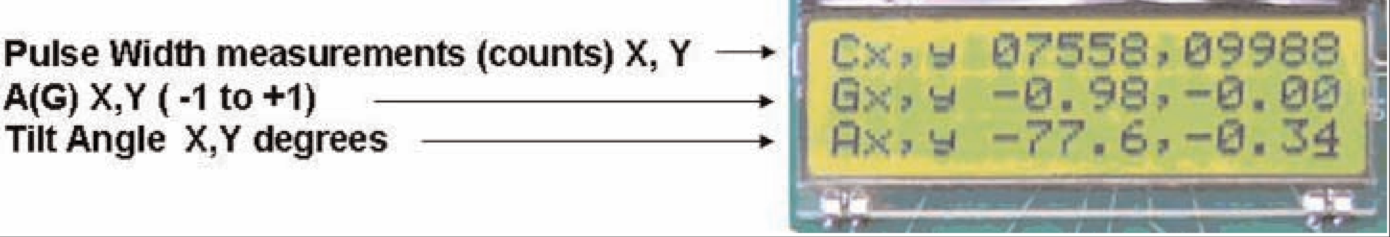
Accelerometer Experiment

The accelerometer is the MX2125 dual axis unit offered by **Parallax.com** and provides the X and Y output PWM pulse corresponding to acceleration forces acting on each of these axis. IC1 connects to the X output of MX2125 using pin 8 of the I/O expansion. IC2 connects to the Y output of MX2125 using pin 7 of the I/O expansion bus. A hook-up diagram is supplied (see **Figure 8**). Fortunately, the MX2125 can operate in a +3.3V



■ FIGURE 8. Accelerometer hook-up.

■ FIGURE 9. Accelerometer display.



environment so no additional electronics are needed. The key C functions for this demo are:

- **capture_IC1 ()** — This function sets up IC1 and TMR3 to capture the X axis incoming pulse edges and make a pulse width measurement. The measured pulse width is directly related to the X axis acceleration. IC1 interrupts are turned on by this function, and it waits on this interrupt to complete its pulse measurements. The first interrupt occurs when an X pulse leading edge is detected. The TMR3 count value is captured. The IC1 interrupt then automatically switches over to capture the associated trailing edge pulse. Once captured, the trailing edge is then subtracted from the leading edge; the interrupt is turned off; and this pulse width is captured in variable pw1 for the X axis.
- **capture_IC2 ()** — This function sets up IC2 and TMR2 to capture the Y axis incoming pulse edges and measures its pulse width. The pulse width is directly related to the Y axis acceleration. This function follows the capture_IC1 () in all aspects with the final Y axis pulse width captured in variable pw2.

Once all the pulse widths for X and Y are captured, some math is required to derive the accelerations on each axis and also to calculate the tilt angle of each axis with earth. No sweat for the PIC24F and its associated C math libraries! We use the manufacturer supplied algorithms to calculate axis acceleration.

A (g) = (pulse width/period -.5)/12.5%

The calculation uses the pulse widths we measured earlier, with a recommended fixed value for a period of 100 Hz.

Next, we calculate tilt angles. A little geometry is required. The desired angle is the inverse sine of A (g) with the earth fixed acceleration — again, the PIC24F to the rescue. Here we use the following:

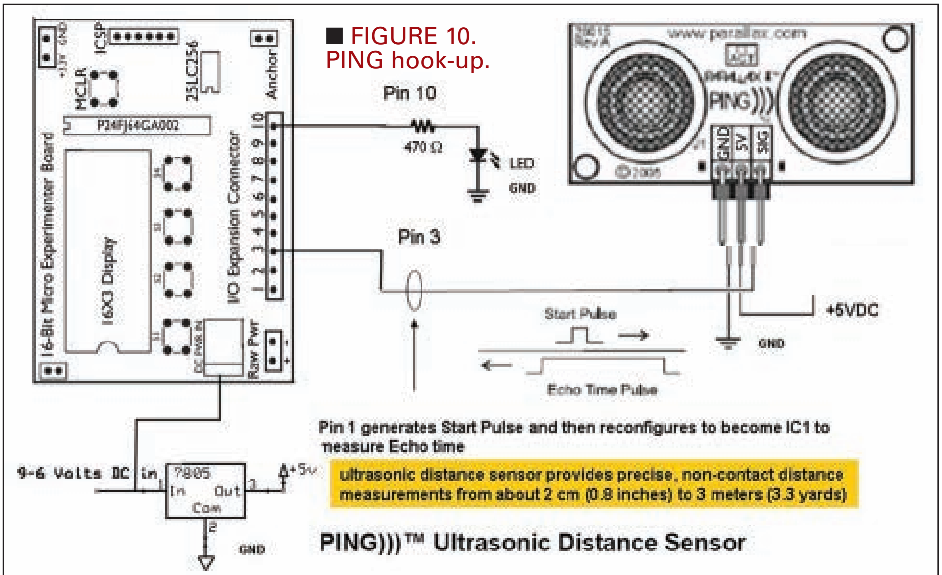
Tilt Angle = inverse sin (A(g)/ g) (where g is normalized earth acceleration or a value of 1).

All measurement is done continuously, and displayed on the LCD (see **Figure 9**) so you can see pulse widths, g forces, and tilt angles. We use an earlier LCD C library. The demo code is ACCELEROMETERDEMO.

The ping measurement allows us to perform distance measurements to a target using acoustic (ultra-sound) echoing. Parallax makes a sensor-designated "PING." It uses a single wire for both signal in (echo return pulse) and control out (initialization pulse). The length of the echo is critical in that its length represents the distance to the target. In this case, we have only one pulse to measure, so IC1 can do the job. However, because the same wire must also initiate the command to PING, it must also generate a pulse output — no problem for the PIC24F. Pin 3 of the Experimenter I/O expansion bus is first configured as a digital output to generate the required command pulse and then is immediately configured as a follow-on to this as input IC1 to measure the return pulse width.

We use the same trick we used before with the accelerometer. Have the IC1 interrupt measure both pulse leading edge time and trailing edge time, then subtract the two to derive the pulse width. Pin 10 of the I/O expansion bus drives an LED through a 470 ohm resistor that flashes each time a PING update occurs. Use the LCD C library mentioned earlier. The demo code is PINGDEMO and a hook-up diagram is supplied (see **Figure 10**). The critical C functions are discussed below. Note the similarity with the accelerometer experiment:

■ FIGURE 10. PING hook-up.



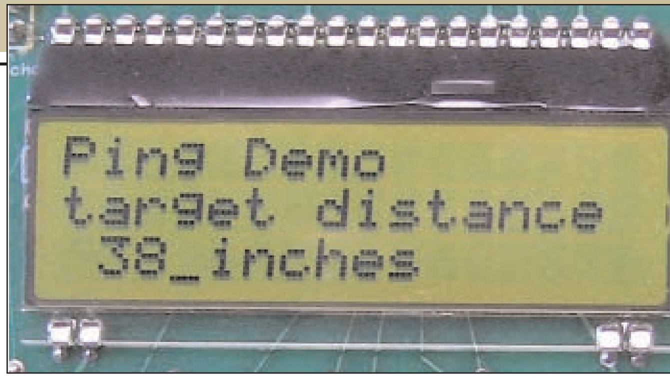
A complete kit to go with this series of articles can be purchased online from the *Nuts & Volts* Webstore at **www.nutsvolts.com** or call our order desk at **800-783-4624**.

- **Ping ()** — This function sets up IC1 and TMR2 to capture the echo incoming pulse edges and make measurements on the pulse width. The pulse width is directly related to the distance to the target. IC1 interrupts are turned on by this function, and it waits on the interrupts to complete its pulse measurements before turning IC1 interrupts off. The first interrupt occurs when an echo pulse leading edge is detected. The TMR2 count value is captured automatically. Once captured, the trailing edge is subtracted from the leading edge and the interrupt is shut down with the pulse width captured in the variable measure.

The main code takes the measured pulse width and calculates the value in inches. The following formula is supplied by vendor:

Inches = (measure/2)/75

The inches value is converted to ASCII and displayed on the LCD (see **Figure 11**). The whole measurement process is continuously repeated and values are updated and displayed.



■ FIGURE 11. PING display.

In Conclusion

We covered a lot of ground — some of you may have seen it before (in other implementations). The bottom line is that the material presented leverages a 16-bit environment and specifically the Experimenter PIC24F and alot of its extensive pulse operations. We really haven't covered all the capabilities yet, so stand by. The total PIC24F pulse operation is impressive and you can mix and match as well as scale up all the material presented here for your next application. **NV**

PARTS LIST

QTY	DESCRIPTION/PART NUMBER
RGB Experiment	
1	RGB LED SPARKFUN COM-09264
1	10K POT
3	100 OHM resistors (1/4 watt)
SERVO Experiment	
1	LM324 IC quad op-amp 14-pin DIP
1	7805 +5V regulator (three-terminal)
4	Parallax (Futaba) standard servos
4	10K resistors (1/4 watt)
1	10K POT
MOTOR Experiment	
1	74HC04 IC HEX inverter 14-pin DIP
1	L293D IC dual half bridge 16-pin DIP
1	7805 +5V regulator (three-terminal)
1	10K POT
2	TOY DC motors (+3-6V)
Accelerometer Experiment	
1	Parallax MX2125 dual axis accelerometer
2	220 ohm resistors (1/4 watt)
PING Experiment	
1	Parallax PING ULTRASONIC sensor
1	7805 +5V regulator (three-terminal)
1	470 ohm resistor
1	RED LED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RCDR
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SW2
SW3
VHF/ UHF RCVR
SA
SW4
SW5
SW6
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■ BY FRED EADY

TAKING USB DOWNSTREAM

Up to this point, we've been working our USB device magic on an upstream connection to a USB host. The time has come to take on USB host responsibilities and originate a downstream connection from the Type A USB connector of a USB host we will design and assemble. We've covered USB fundamentals in past Design Cycle conversations. So, if we run across a USB-related tidbit that needs clarification, we'll take care of that business as we find it. Our mission is to gain enough knowledge to design, build, and program a piece of embedded USB host hardware.

THE USB HOST CORE DEVICE

FTDI has established a reputation of delivering easy to deploy USB functionality to our little world of microcontrollers. So, it stands to reason that our USB host project will be anchored on a USB integrated circuit produced by FTDI. For those of you not familiar with the term "FTDI," it is short for Future Technology Devices International. There's a good chance that the RS-232-to-USB converter dongle you plug into your laptop or desktop PC is loaded with an FTDI USB-to-RS-232 converter IC (such as the FT232R USB UART IC).

FTDI USB devices (such as the FT232R) are intended to be integrated into new USB designs, as well as legacy RS-232 designs. In the case of RS-232 designs, parts like the FT232R are designed to transparently replace the RS-232 hardware. Utilizing an FTDI USB-to-UART device does not require the user to write any USB driver code as the FTDI device emulates the RS-232 hardware it displaced. All of the USB responsibilities (including the USB physical hardware and USB logic) are encapsulated within the FT232R USB UART IC.

Our USB host project will revolve around the brand new FTDI Vinculum-II Embedded Dual USB Host Controller IC which is more than just a platform that supports host USB operations. The Vinculum-II can also be programmed to run an application in addition to handling USB host duties. In many ways, the Vinculum-II looks and acts like a microcontroller. We recently discussed the PIC24FJ256GB106's peripheral pin select feature which allows the programmer to assign the PIC's peripherals to alternate sets of I/O pins. Guess what? The Vinculum-II's on-chip VNC2 IOMux performs the identical pin assignment duty for the Vinculum-II peripherals.

A programmable 3 Mbaud UART and a pair of SPI portals add to the Vinculum-II controller IC's microcontroller feel. Three 16-bit counters are available to us with a fourth 16-bit timer dedicated to the RTOS (Real Time Operating System). The available 16-bit count-down timers can be configured for one shot or auto-reload operation with an option to interrupt on zero. The Vinculum-II's 16-bit timers also play a major part in the generation of PWM signals which can stream from any or all of the Vinculum-II's eight PWM outputs. The SPI portals and UART cover the Vinculum-II's serial I/O capabilities while an eight-bit wide FIFO interface handles the parallel interface duty.

As you would expect, the I/O peripherals are supported by 128K x 16 of E-Flash program memory and 4K x 32 (16K x 8) of data RAM. Judging from the bit width assigned to the timers, program Flash, and data RAM, the Vinculum-II is a 16-bit device. In fact, it is indeed a 16-bit device that employs Harvard architecture. Harvard architecture places the program memory and data memory in separate data spaces.

There are three Vinculum-II variants with differing numbers of available GPIO pins. Our design will use the largest Vinculum-II variant which is housed in a 64-pin package that puts 44 GPIO pins at our disposal. There is also a 32-pin Vinculum-II part that supports 12 I/O pins and a 48-pin part which exposes 28 I/O pins.

All of the aforementioned Vinculum-II hardware is supported by a peripheral library, a VNC2 IOMux configuration utility, an IDE, and a C compiler. In keeping with my promise of inexpensive projects, you'll need only to purchase the Vinculum-II hardware components as the firmware development tools are free for a download from the FTDI site. The C compiler and IDE contain all of the "smarts" to debug and program a Vinculum-II via the integral debugger interface module.

Despite all of the USB power wielded by the Vinculum-II, it is imperative that we assemble the necessary USB hardware to allow the programming and debugging of the IC. With that, for the past couple of days I've been collecting all of the necessary electronic parts to build a Vinculum-II USB host platform complete with debugger/programmer hardware. Let's begin by identifying the electronic parts we'll need for the debugger/programmer interface, examining their purpose, and punching out a preliminary design.

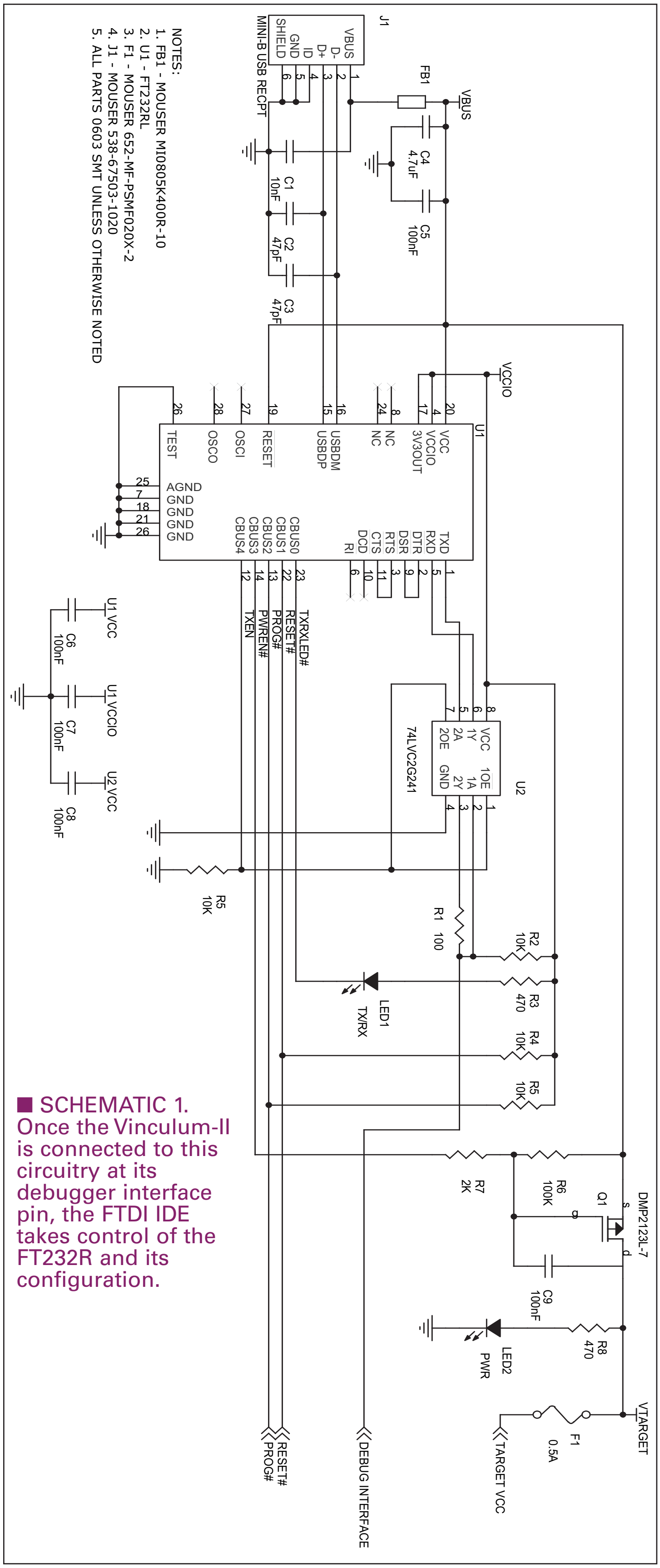
COLLECTING VINCULUM-II DEBUGGER/PROGRAMMER PARTS

For starters, we've got to come up with each and every part depicted in **Schematic 1**. The good news is that this parts acquisition mission will be a walk in the park. The MINI-B USB receptacle (J1) is the same part we've used in every Design Cycle USB project to date. The ferrite bead (FB1) and capacitors C1, C2, and C3 are included solely for EMI suppression. The FT232R USB UART IC datasheet states that the capacitors supporting the USB inputs are optional. However, as they do serve a useful purpose, we're going to include them in our design.

The VBUS voltage is normally provided by the USB host. Since VBUS is generated external to our circuitry, we need to attenuate any spurious noise that may try to sneak in over the USB cable run. With that, capacitors C4 and C5 are designed in as VBUS filter capacitors. Note the absence of a polarity marker on C4 as it is a high-capacitance 0603 ceramic SMT part.

The FT232R can operate with an externally influenced clock or its internal oscillator. Reducing the parts count automatically reduces the project cost. So, we'll forego the use of an external 12 MHz crystal on pins 27 and 28 of the FT232R and use its internal oscillator. Recall my first law of embedded computing: "Nothing is free." Using the FT232R's internal oscillator requires that a minimum of +4.0 volts be applied to its VCC pin. When using an external 12 MHz crystal to clock the FT232R's innards, we can apply as little as +3.3 volts to the FT232R's VCC pin. The VBUS voltage level is nominally +5.0 volts which exceeds the +4.0 volt minimum we need at the VCC pin.

As you can see in **Figure 1**, the VBUS input voltage feeds a 3.3 volt LDO voltage regulator cell. The +3.3 volt power rail produced by the LDO voltage regulator



■ SCHEMATIC 1. Once the Vinculum-II is connected to this circuitry at its debugger interface pin, the FTDI IDE takes control of the FT232R and its configuration.

provides power for the USB transceiver and the internal 3.5KΩ USBDP pull-up resistor. The Vinculum-II is a 3.3 volt

part. So, we'll also use the output of the FT232R's LDO voltage regulator to drive the FT232R's I/O pins at 3.3 volt logic levels via the VCCIO power input pin.

In reality, the FT232R's active-low RESET pin is internally pulled up and can be left disconnected. The datasheet gives us the option to tie the RESET pin logically high or control it with an external device such as a microcontroller. There are no microcontroller I/O pins available to us in this situation. So, to play it safe and avoid any possibility of a spurious reset, we'll physically connect the FT232R's RESET pin to VBUS.

The Vinculum-II's debug interface is a single-wire bidirectional data pipe. To adapt the FT232R's two-wire TXD/RXD serial interface to the Vinculum-II's single-wire debug interface, we'll multiplex the TXD and RXD signals using a 74LVC2G241 dual three-state buffer. The data flow direction on the Vinculum-II interface is controlled by one of the FT232R's programmable CBUS I/O pins (CBUS4).

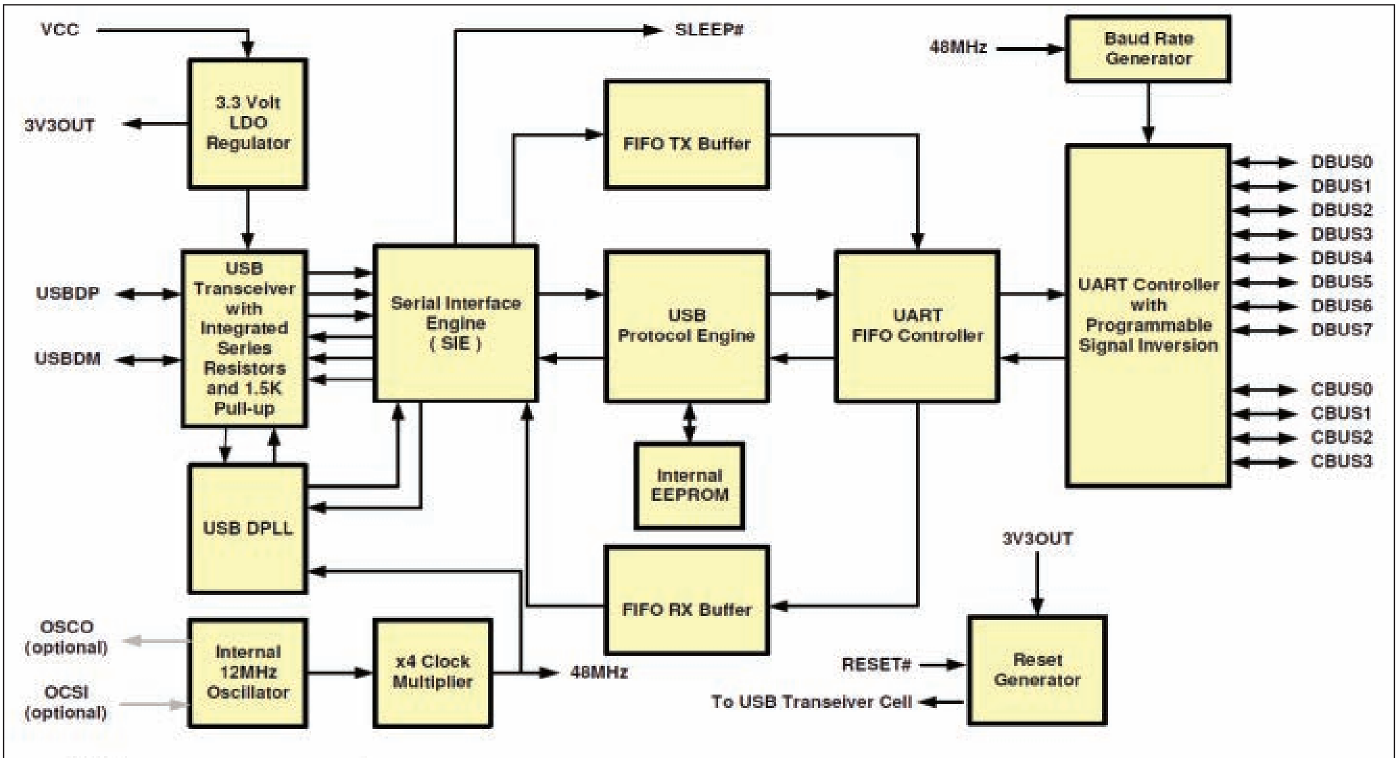
The CBUS I/O configuration is retained within the bit structure of the FT232R's internal 1024-bit EEPROM. However, we can view and change the CBUS I/O configuration using the FTDI FT_Prog Utility which (like most other FTDI tools) is a free download. With the help of this Utility, let's see if we can make some educated guesses as to how the CBUS I/O is configured for the Vinculum-II debug interface application.

CBUS0 is a configurable I/O pin that defaults to an active-low TXLED# output signal. The "#" character denotes an active-low FT232R or Vinculum-II signal. In its default mode, this signal pulses logically low for transmission events. According to our debug interface layout, CBUS0 is configured as TXRXLED#. As you can see in **Screenshot 1**, TXRXLED# is termed TX & RXLED# in the FT_Prog Utility and causes CBUS0 to pulse logically low and blink the TX/RX LED at every TXD or RXD bit that flies by.

CBUS0 is a configurable I/O pin that defaults to an active-low TXLED# output signal. The "#" character denotes an active-low FT232R or Vinculum-II signal. In its default mode, this signal pulses logically low for transmission events. According to our debug interface layout, CBUS0 is configured as TXRXLED#. TXRXLED# is termed TX & RXLED# in the FT_Prog Utility and causes CBUS0 to pulse logically low and blink the TX/RX LED at every TXD or RXD bit that flies by.

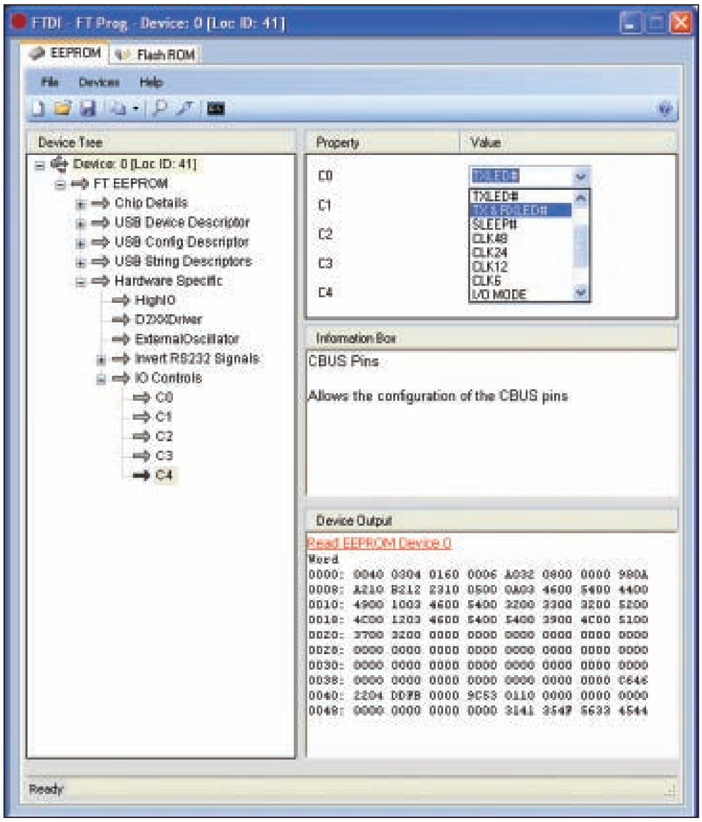
CBUS1 is also a configurable I/O pin which defaults to RXLED#. When CBUS1 is configured as RXLED#, receive events will trigger this pin to produce an active-low pulse. Our application calls for this pin to act as the Vinculum-II's RESET# interface. The RESET# signal is not a native FT232R signal and is particular to the Vinculum-II. So, there is no FT_Prog Utility selection we can make for CBUS1. I just happen to have my donkey standing by and according to the snorts and hee-haws, I/O mode may be our best configuration choice for this pin. After all, we only need to have CBUS1 go logically low on command. The same holds true for the CBUS2 signal PROG# which is also a Vinculum-II-only signal. Note that both the RESET# and PROG# signals are pulled up with 10KΩ resistors.

CBUS3 is just fine as it is. The default state of PWREN# matches our desired configuration for this CBUS



■ FIGURE 1. Once again, a picture is worth a thousand words. This is a block diagram of the FT232R's system cells.

■ SCREENSHOT 1. The FT_Prog Utility can be used to inspect and/or change the FT232R's innards. We're about to alter the default CBUSO configuration TXLED# to TX & RXLED# in this shot.



I/O pin. The PWREN# signal is used to activate external current loads once the FT232R has been successfully configured, and deactivate those current loads when the device enters USB suspend mode. We've emulated the functionality of this pin with a microcontroller I/O pin in past Design Cycle USB projects.

Looking at **Schematic 1** again, the PWREN# signal drives the logic-level gate of a P-channel MOSFET. Resistor R6 insures that the DMP2123L-7's gate is pulled to VBUS when the PWREN# signal is inactive (logically high). When the PWREN# pin transitions to its active-low state, resistor R7 and capacitor C9 act as a soft start circuit. The soft start configuration prevents the FT232R or any attached USB host from resetting due to the transient surge current that occurs when the MOSFET switches on.

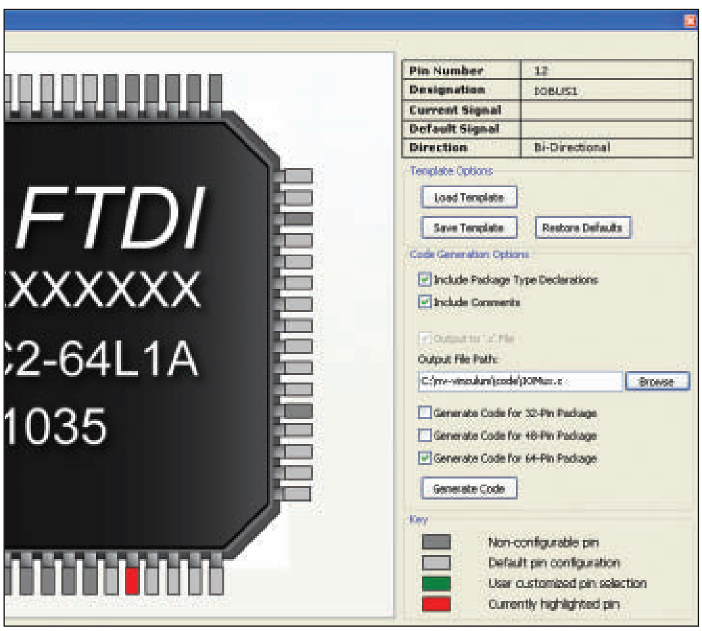
CBUS4 is output only and defaults as an active-low SLEEP# output. In **Schematic 1**, CBUS4 is labeled as the active-high TXEN pin. Recall that the TXEN signal is used to control the flow of debugger interface data through the three-state buffer pair. The FT_Prog Utility calls our TXEN signal TXDEN. TXDEN is normally used in half duplex RS-485 links to switch the direction of transmission. In that we're also switching transmit and receive circuitry, our application of TXDEN is very similar to its originally intended purpose. When TXEN is logically high, data is allowed to flow from the FT232R's TXD pin, to the 2A input of the 74LVC2G241 three-state buffer, and out of the 2Y buffer output to the Vinculum-II's debugger interface. Data flowing from the Vinculum-II through the debugger interface is allowed to flow into the FT232R via the alternate gate of the three-state buffer when TXEN is logically low.

If you look back at some of the previous Design Cycle USB designs, you'll see that we used a TPS2041BDBVT instead of a MOSFET to switch the VBUS voltage to an external load. The TPS2041BDBVT is equipped with an OC (Over Current) output pin which we monitored with the I/O pin of a microcontroller. In our Vinculum-II debugger/programmer design, the TPS2041BDBVT and associated microcontroller are replaced by a DMP2123L-7 and an SMT PTC fuse. Resettable fuse F1 holds at 200 mA and trips at 500 mA.

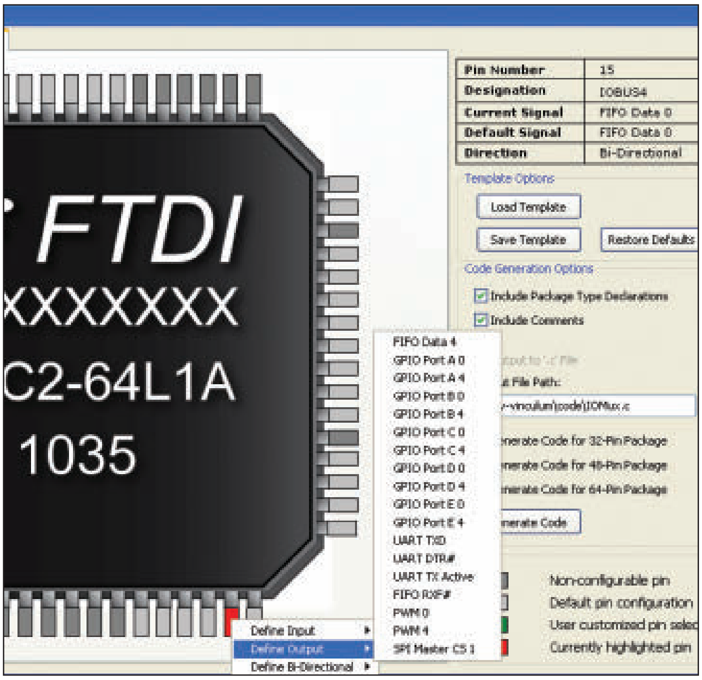
If you wish to consider the TPS2041BDBVT as an alternative power control design, it is rated for 500 mA continuous, and includes circuitry that will limit the current to a safe level in the event of a continuous or severe overload condition. However, if your Vinculum-II design will draw current that is always hovering near the 500 mA USB portal maximum, you will need to provide external power to your circuitry regardless of the power control design you choose to use.

The debug interface circuitry we've just designed can stand alone or be included on the Vinculum-II application circuit board. Low-power Vinculum-II applications will want to see the this circuitry out board. Vinculum-II application development platforms will benefit by including the debug interface circuitry on board.

As it turns out, we can ride our donkey all day long since the Vinculum-II IDE takes care of configuring the FT232R's CBUS I/O pins for the debug interface. With that, let's talk a little about the Vinculum-II.



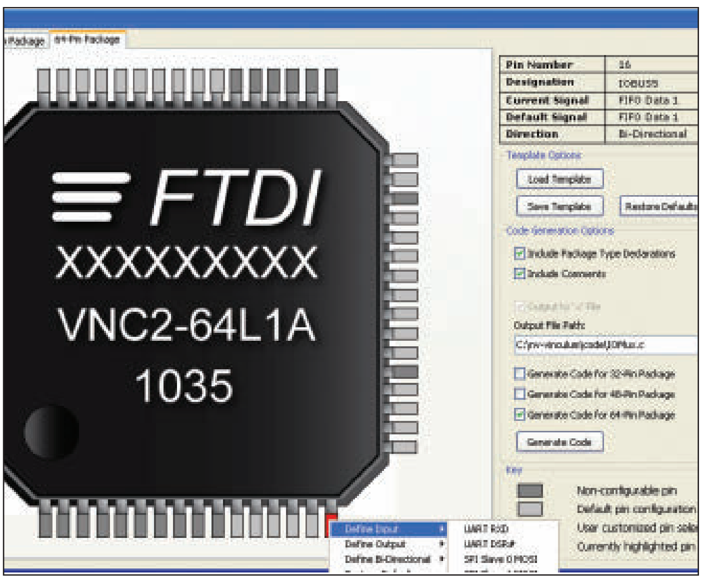
■ SCREENSHOT 2. Not only does this utility spill the beans on the Vinculum-II's I/O, it writes the code too. To keep things simple, I've asked the utility to only write code for the 64-pin part.



■ SCREENSHOT 3. Every possible I/O assignment for IOBUS4 — including the default IOBUS pin assignment — belongs to I/O Mux Group 0.

VINCULUM-II PRIMER

Other than locking yourself into a dimly lit office and absorbing the Vinculum-II datasheet, the best way to come up to speed on the operation of the Vinculum-II is to fiddle with the VNC2 IOMux Config utility. A 64-pin virtual Vinculum-II is captured in **Screenshot 2**. Note that I have selected pin 12 which defaults to a bi-directional I/O



■ SCREENSHOT 4. My first rule of embedded computing is evident here. If we reassign the UART I/O pins and want to use the FIFO, we must also reassign the default FIFO pins. Nothing is free when it comes to embedded computing.

Special Thanks

Special thanks to FTDI's Damon Barsuglia for his support.

pin. If you're wondering why I didn't select pin 11, check out the datasheet and application notes. You'll be warned more than once that pin 11 is the debugger interface pin and it is not recommended to reassign this pin.

To aid in the logical assignment of peripheral I/O, the Vinculum-II's I/O pins are arranged into I/O Mux Groups. Each IOBUS pin in an I/O Mux Group is four IOBUS pins away from others in the same group. For instance, IOBUS1 (pin 12) is part of I/O Mux Group 1. IOBUS5 is also part of I/O Mux Group 1, as is IOBUS9 and so forth. The debugger interface pin (IOBUS0) belongs to I/O Mux Group 0. There are a total of four groups. That means the 64-pin Vinculum-II can select up to 11 pins from each group.

Pin 39 of the Vinculum-II (IOBUS20) defaults to the UART TXD pin which is obviously an output. IOBUS20 belongs to I/O Mux Group 0. UART TXD cannot be reassigned to any pin that is not part of I/O Mux Group 0. So, what if we wanted to reassign the UART TXD function to a pin in the pin 1-16 area? According to the VNC2 IOMux Config utility, pins 11 (IOBUS0) and 15 (IOBUS4) are the only possible destinations in the pin 1-16 area. We know that reassigning a peripheral I/O to pin 11 is a NO NO. So, if we believe what we see in **Screenshot 3**, we must consider placing the UART TXD output at pin 15.

Pin 40 (IOBUS21) is part of I/O Mux Group 1 and defaults to UART RXD. For the purposes of PCB design, it is most convenient to keep the UART TXD and RXD I/O pins next to each other. This idea is carried over to the Vinculum-II as its I/O logic is designed to keep the TXD and RXD I/O pins adjacent no matter where they are allowed to be assigned. We could assign UART RXD to pin 12 (IOBUS1). However, if we follow the rules of reassignment, pin 11 cannot be reassigned to support the UART TXD function. Thus, our adjacent pin requirement could not be met. According to **Screenshot 4**, the next available I/O Mux Group 1 pin is pin 16 (IOBUS5); placing the UART RXD function here keeps the UART TXD and UART RXD pins side by side.

The VNC2 IOMux Config utility keeps us out of trouble when it comes to reassigning peripheral I/O pins. However, its greater strength is its ability to generate the code behind the pin swaps. Here's our UART swap code:

```
#include "vos.h"

void SetupIOMUX()
{
        unsigned char packageType;

        packageType = vos_get_package_type();

        //*******************************
        //Initialise the IOMUX parameters
        //*******************************

        if(packageType == VINCULUM_II_64_PIN)
```

```
        {
        // UART TXD to pin 15 as Output.
        vos_iomux_define_output(15,
        IOMUX_OUT_UART_TXD);
        // UART RXD to pin 16 as Input.
        vos_iomux_define_input(16,
        IOMUX_IN_UART_RXD);
        //  to pin 39 as Output.
        vos_iomux_define_output(39, IOMUX_OUT_);
        //  to pin 40 as Input.
        vos_iomux_define_input(40, IOMUX_IN_);
        }
}
```

Since we didn't specify what to do with the original UART TXD and RXD pins, the VNC2 IOMux Config utility put them into limbo as there are no aliases for IOMUX_OUT_ and IOMUX_IN_. The C compiler burps on those unknown assignments. This is a better solution:

```
   if(packageType == VINCULUM_II_64_PIN)
    {
        // UART TXD to pin 15 as Output.
        vos_iomux_define_output(15,
        IOMUX_OUT_UART_TXD);
        // UART RXD to pin 16 as Input.
        vos_iomux_define_input(16,
        IOMUX_IN_UART_RXD);
        // GPIO Port A 0 to pin 39 as Output.
        vos_iomux_define_output(39,
        IOMUX_OUT_GPIO_PORT_A_0);
        // GPIO Port A 1 to pin 40 as Output.
        vos_iomux_define_output(40,
        IOMUX_OUT_GPIO_PORT_A_1);
    }
}
```

SOURCES

FTDI
Vinculum-II Embedded Dual USB Host Controller
VNC2 IOMux Config Utility
FT_Prog Utility
FT232R USB UART IC
www.ftdichip.com

We've simply used the VNC2 IOMux Config utility to assign the orphaned UART I/O pins a new job on the PORT A GPIO farm.

Coding the Vinculum-II in C is really no different than coding any other microcontroller in C. However, as you might imagine, the Vinculum-II code has its own "taste." We'll put a pallate on the Vinculum-II's C "ingredients" as we design and build more hardware.

NEXT TIME

I'm out of paper. So, when we meet again we'll put together a Vinculum-II hardware design to complement the FT232R debugger/programmer hardware design we assembled in this discussion. **NV**

Fred Eady can be contacted via email at fred@edtp.com.

FUNDAMENTALS FOR THE BEGINNER

A kit for these experiments can be purchased from the *Nuts & Volts* Webstore at **www.nutsvolts.com** or call us at **800-783-4624**.

HOW A CAPACITOR WORKS

The function of a capacitor is to store an electrical charge. In this circuit, we will watch an LED slowly dim as the capacitor discharges.

1. Build the Circuit.

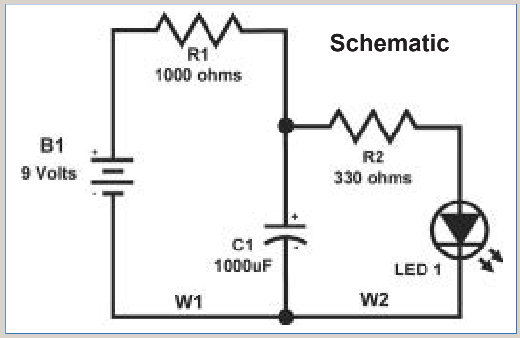
Using the schematic along with the pictorial diagram, place the components on a solderless breadboard as shown. Verify that your wiring is correct.

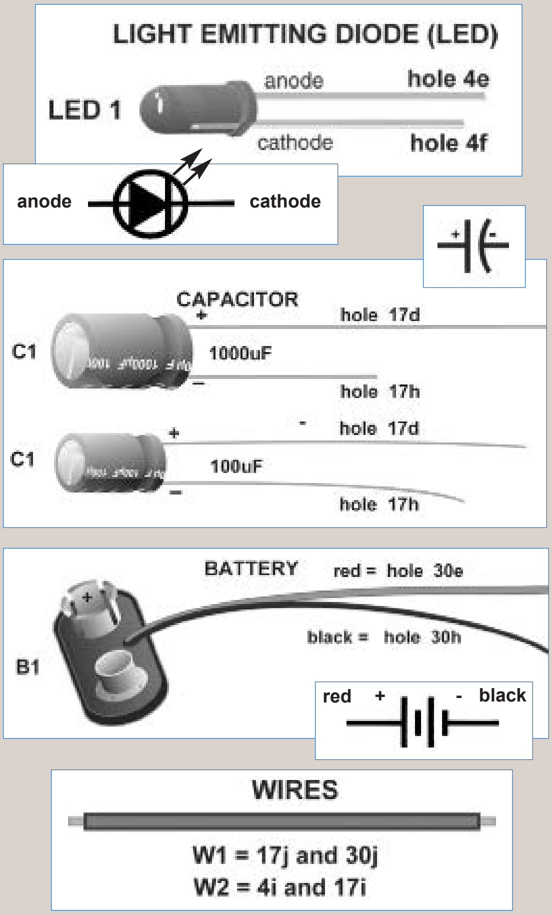
2. Do the Experiment.

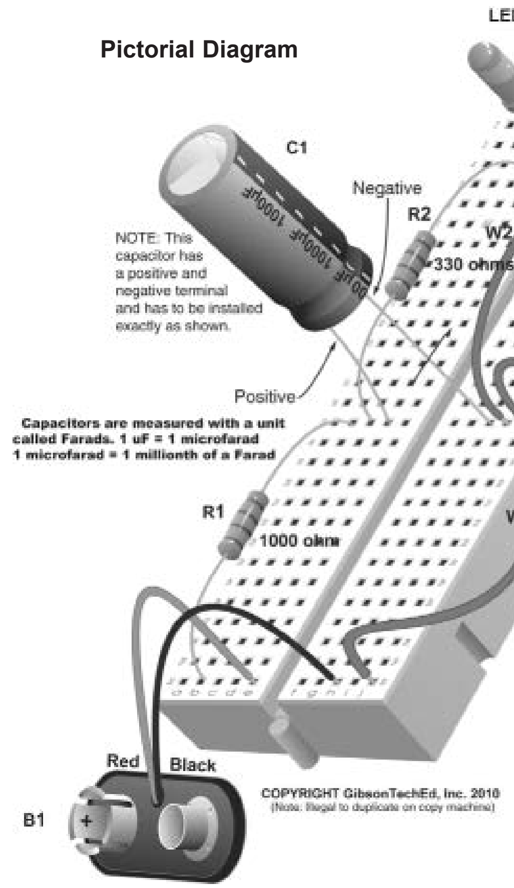
__Theory:__ Electronics flow from the battery through the LED, through the resistors, and back to the battery. Electrons also flow from the battery to charge up the capacitor. When we remove the battery from the circuit, electrons in the charged capacitor will flow through the LED and keep it lit until the capacitor sufficiently discharges.

__Procedure:__ Connect a nine-volt battery to the battery snap and observe that the LED is lit. Next, remove one lead of the battery snap from the circuit board and observe that the LED remains lit for a moment. Now, change the capacitor to the 100 µF, then connect and disconnect the battery. Do this again with the 1,000 µF and observe the LED.

As you should have seen, the LED remains lit temporarily after the battery is disconnected from the circuit because the electrical energy stored in the capacitor flows from the negative side of the capacitor through the LED and the 330 ohm resistor to the positive side of the capacitor. The LED should have remained lit longer with the 1,000 µF capacitor than it did with the 100 µF.







These experiments are provided by GSSTechEd.
www.gssteched.com

You can order parts for this experiment from their website as follows:

GK0153	330 ohm
GK01065	1,000 ohm
GK06001	LED
GK05009	1,000 MFD CAP
GK05005	100 MFD CAP
GK35002	Battery Snap
GK45011	Solid Insulated Wire

■ BY LOUIS E. FRENZEL W5LEF

CRYSTAL CLOCK OSCILLATORS ARE THE HEART OF ALL COMMUNICATIONS PRODUCTS

If you look inside any electronic product today, there are a few circuits and components that are common to all of them. For example, every product contains at least one microcontroller that runs it. Another circuit that you will see — especially in communications products — is a crystal oscillator or clock. This circuit generates precise timing signals that control everything else — including that microcontroller. In communications gear like radios, that crystal is the source of the exact operating frequencies needed for wireless operations. Here is a look at these critical circuits.

WHY CRYSTALS?

The need for precise frequency control in electronics is critical. In microcontroller applications, the need is for accurate timing of all processor functions. In communications, precise frequencies are needed for all wireless operations because they are restricted to specific frequencies and bands by the Federal Communications Commission (FCC). Penalties for frequency violations are expensive and severe. Crystals ensure not only accurate timing in processor operations but also in setting the operating frequencies of any radio.

You can make oscillators out of resonant inductor-capacitor (LC) circuits or RC charge/discharge circuits. They work well, but their limitations are severe. First, it is difficult to get just the right frequency. Component tolerances are just not good enough, even if the components are made variable. Second, even if you can tune an LC or RC oscillator to the desired frequency, it just won't be stable enough to maintain that frequency. Oscillators are not so stable. Their frequency changes with temperature, vibration, and other physical conditions. These oscillators drift off frequency over time and quickly lose their timing accuracy or frequency settings.

The solution is to use a crystal oscillator. A crystal is a piece of natural quartz that has been cut into a thin element that will vibrate at a specific frequency. The shape and thickness of the quartz sets the frequency. That frequency can be very precisely determined to within a fraction of a percent. Furthermore, the quartz crystal has amazing stability. It can maintain that precise frequency over a long period despite temperature variations and power supply changes.

HOW CRYSTALS WORK

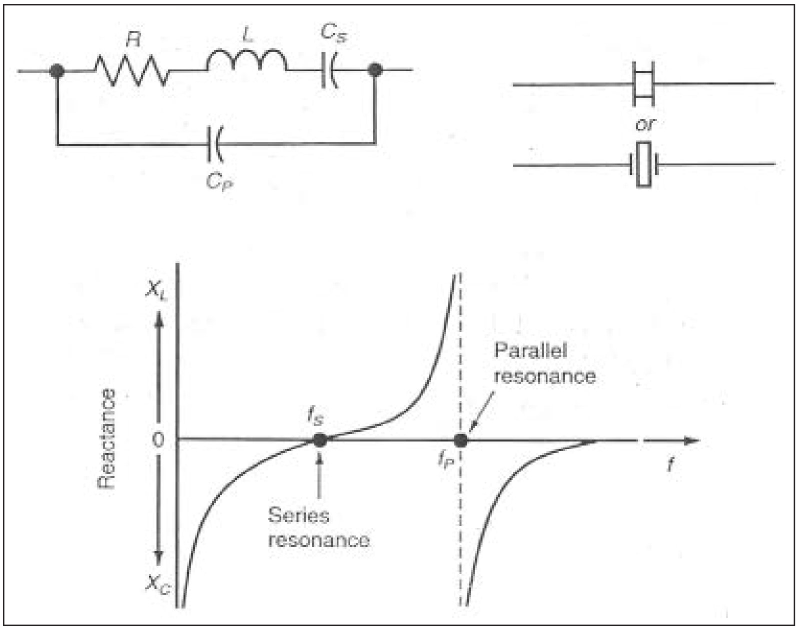
The equivalent circuit of a crystal is a simple series-parallel RLC circuit as shown in **Figure 1**. The components R, L, and Cs form a serial resonant circuit. At resonance, the reactance of the inductor and capacitor cancel out leaving only the equivalent resistance R in parallel with Cp.

At a slightly higher frequency, the inductance and the parallel capacitance Cp form a parallel resonant circuit with its near infinite impedance. **Figure 1** shows the reactance variations. Note also the schematic symbols for a crystal are sometimes abbreviated XTAL. The lower symbol is the more widely used. The crystal has an incredibly high Q so the resonant frequencies are very sharply defined.

The idea is to connect this crystal into a simple oscillator circuit. You can do this with a single transistor. While you can still do that, it is more common today to just buy a crystal oscillator. They come packaged as a

single integrated circuit. And they are cheap — less than $2 in single quantities. The crystal is already wired into the on-chip oscillator circuitry. All you need to do is apply DC power (usually 3.3 or 5 volts) and out comes either a sine wave or rectangular wave signal ready to use. The output voltage range is several volts.

The frequency range for crystals is very wide so you can get almost anything. The lowest frequencies are 32.768 kHz and 100 kHz. The highest is about 300 MHz. Most popular crystal frequencies are in the 10 MHz to 200 MHz range.



■ FIGURE 1. The equivalent electrical circuit of a quartz crystal and its schematic symbols. The curve shows the reactance variations over frequency. *Courtesy McGraw Hill, Principles of Electronic Communication, 3rd edition, 2008.*

TYPES OF CRYSTAL OSCILLATORS

Crystal oscillators come in a variety of types, shapes, and sizes. The simplest device is the plain vanilla crystal oscillator (XO). It comes in a fixed frequency value that is commonly with an accuracy of (10) several hundred parts per million (ppm) or in the 10^{-4} to 10^{-5}. These are for the least critical applications such as embedded controller clocks. You can get one at a common frequency of 10 MHz or 20 MHz for less than a dollar.

A variation of the basic XO is the TCXO or temperature compensated crystal oscillator. Since all crystal oscillators are subject to frequency changes with temperature — small as they are — for more critical applications special circuitry is used to correct for frequency variations. A feedback loop is created with a thermistor temperature sensor in a circuit that drives a varactor or voltage variable capacitor. This varactor connects to the crystal to provide frequency adjustments. The result is an amazingly precise and stable oscillator. A frequency accuracy and stability in the 10^{-5} to 10^{-7} is typical. End products requiring that kind of precision and stability are cell phones and other two-way radios.

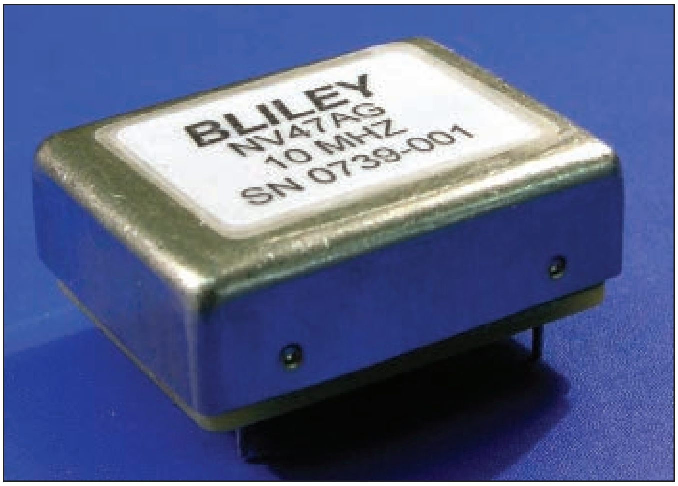
Another type of oscillator is the VCXO or voltage controlled crystal oscillator. A varactor is connected in series or parallel with the crystal to "pull" its frequency over a narrow range. These units are used primarily in phase-locked loops (PLLs) for frequency multiplication or frequency synthesis.

The other type of oscillator is the oven-controlled crystal oscillator or OCXO (see **Figure 2**). As the name implies, the oscillator comes in a thermally enclosed package with a small electric heating element that is cycled off and on in a closed-loop controller to maintain a super constant temperature. With this arrangement, accuracy and stability is in the 10^{-7} to 10^{-10} range. This is good enough for real critical applications like cellular basestations and other telecommunications networks.

CRITICAL SPECIFICATIONS

Obviously, the main specification is the frequency of operation. Frequencies up to about 200 MHz are available. Higher frequencies can also be had, but in some cases a PLL frequency multiplier is used. Most crystal companies stock common frequencies, but you can always order a special one (at extra cost).

Frequency accuracy is the next most important spec. It is just a measure of how close to the desired frequency the crystal actually is. It is usually given in ppm or as a percentage, such as 10^{-4} or 0.0001 or 0.01% (see the



■ FIGURE 2. A common crystal oscillator in a metal can— the Bliley Technologies NV47AG OCXO. It comes in frequencies from 5 to 13 MHz. It is designed for use in wireless basestations, GPS infrastructures, and test equipment. The basic stability is ± 4.6 ppm.

■ FIGURE 3.Crystal oscillator in a surface-mount package. Fox Electronics XO and VCXO SMD oscillators are available in frequencies from 750 kHz to 1.35 GHz with stabilities to 20 ppm. Phase jitter is typically less than 1 ps. Typical package sizes are 5 x 3.2 mm and 7 x 5 mm.

sidebar). Most crystals are selected based on the needs of the applications (the FCC states the accuracy for many applications).

Next comes frequency stability. This is a measure of how the frequency varies over time with temperature and other variations. This is usually stated in ppm over a given temperature range like -40 to +85 degrees C. Part of the stability spec is aging; that is how the frequency may vary over a longer period of time (like weeks or months).

Output voltage and interface are one more specification. Most crystal oscillators generate a rectangular wave compatible with old style TTL circuits or (in some cases) with the newer lower voltage interfaces like HCMOS, LVDS, PECL, or CML. Sine wave output is also available if needed.

Phase noise is a critical spec especially for crystals in above the 100 MHz range. These are used in telecommunications applications. Phase noise is really just some short term frequency variations around the center frequency. It is sometimes called jitter. In any case, it is really small frequency or phase variations that look like FM or PM.

The spec is given in dBc/Hz or the decibel value of the sidebands produced compared to the center or carrier frequency a specific number of Hz (10 kHz, 100 kHz, or 1 MHz) from the carrier. A typical value may be -120 dBc/10 kHz.

Finally, the package. An older (but still used) package is the metal can like that in **Figure 2**. They have designations like HC-45, HC-49, HC-50, or HC-51. The newer packages are surface-mount devices (SMD) like the one in **Figure 3**. This one is 5 x 7 mm — a common size. Even smaller units are available now.

OPTIONAL OSCILLATORS

While crystal oscillators are the most common, you can get several other very precise and stable oscillators, depending on the

PPM

The term parts per million (ppm) is an expression of how far a crystal frequency varies from its main value. This is also expressed as a percentage of deviation from the base frequency. For example, a 200 ppm reading on a 10 MHz crystal means that the deviation is:
(200/1,000,000) x 10,000,000 = 2,000 Hz or 2 kHz.
That translates into a maximum deviation of 2000/10,000,000 or 0.0002 = 2×10^{-4} or 0.02%.

application. A really good but cheap alternative is the ceramic resonator. It is like a crystal, just not as precise or stable. It is still good enough for some microcontroller clocks and the like.

Another variation is the device that uses a PLL frequency multiplier. The crystal and the oscillator with a VCO are all packaged into a single PLL and the frequency of a basic crystal in the 10 to 50 MHz range is multiplied up into the hundreds of MHz range. These are not as stable as a standard oscillator, but are still good. Phase noise is also not good enough for some applications.

Another interesting choice is a surface acoustic wave (SAW) oscillator. SAW devices use an interdigital pattern or a quartz or other base that has a peak response at a fixed frequency. SAW devices are mainly used as VHF and UHF filters but when put into a feedback loop, they oscillate at a specific frequency. You can get frequencies from about 300 MHz to over 1 GHz. The precision and stability are not as good as a crystal but for some uses, they are more than adequate.

MEMS oscillators are also available. These micro electromechanical systems devices are tiny vibrating arms that oscillate at a precise frequency. They are made entirely of silicon on one chip. They are more than accurate enough for some uses but again, not as good as a real crystal.

One really interesting option is the programmable crystal oscillator. These feature a fixed frequency crystal oscillator in a PLL with a programmable frequency divider in the feedback loop. The divider is programmed by an external digital input. A digital PLL is used so precision and stability are just as good as most pure XOs. A good example is Silicon Laboratories Si530, Si550, or Si570 XO/VCXO oscillators that can be ordered in any frequency from 10 MHz to 1,417 MHz.

An internal third overtone crystal operating at 114 MHz stabilizes a digital VCO running at 5 GHz using a PLL multiplier. The multiplier takes advantage of DSP filtering to improve jitter performance A digital VCO and a set of output frequency dividers are used to program the output frequency.

Crystals are everywhere. I bet that you personally own at least a dozen and if you are a heavy electronics user, maybe even more. **NV**

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by Joe Pardue

AVR Memory Part 3: Program Memory In A Flash!

Recap

Last month, we continued our AVR Memory series and discussed the EEPROM. This month, we will look at a special type of EEPROM named Flash that is used by the AVR for storing program memory. We will learn how to store constant data (like sentences) in Flash and how to write code that will read from Flash. We will write pgmtest.c to demonstrate these principles. This program is written in a single file that can be compiled for either the AVR Butterfly (ATmega169), the Arduino hardware (ATmega328), or the BeAVR40 (ATmega644). [The BeAVR40 was shown in *Workshop 22: Busy as a BeAVR* in the May '10 *Nuts & Volts*.]

Why Flash?

We looked at this some in earlier articles but let's revisit the concepts. A computer requires some sort of persistent binary memory for a program. It needs to be persistent so that when the power is turned off, the computer won't forget what it is supposed to do. This persistent memory can be anything that can store binary data, from ordinary switches to rolls of paper tape. To get things moving fast, we need to use electrons. While these computer memories tend to evolve at computer speed, the sweet spot for persistent memory in microcontrollers is now occupied by Flash — a form of EEPROM (Electrically Erasable Programmable Read Only Memory).

The big difference between regular EEPROM and Flash is that the regular kind can have individual bytes written or erased, while the Flash is written or erased in larger groups of bytes called pages. Since the erase/write circuitry is expensive (compared to the memory itself), using pages is considerably cheaper than bytes. The trick is to copy the page about to be written from the Flash to a section of RAM the same size as the page, change it in RAM, erase the Flash page, and then copy the data from the RAM back to the Flash page. We don't need to understand much beyond that this process makes Flash a lot cheaper than other forms of reprogrammable persistent memory.

C Doesn't Know About Flash

The C programming language was designed for Von Neumann memory architecture — a single memory external to the CPU where both the program and data are stored. However, most microcontrollers are designed to use a modified Harvard memory architecture where the program is stored in one type of memory and the data is stored in another. [For AVRs, it is even a bit more complex since many AVRs have the program stored in non-volatile Flash, but the data is mapped to registers and SRAM. So, typical AVRs have four types of memory: EEPROM, registers, SRAM, and Flash.]

The C programming language has often been referred to as a device-independent assembly language. This means that C models a general-purpose computer, but not any specific computer. C doesn't know a lot about how real computer memory is implemented; this is a good thing since virtually every microcontroller family has different ways of handling memory. This separation from the underlying hardware makes C portable in the sense that it leaves figuring out the machine-dependent specifics to the folks who write compilers that translate C into a device specific assembly language

The WinAVR toolset uses the venerable GCC compiler (that is arguably the most important piece of free software ever written). GCC is an acronym for GNU Compiler Collection and GNU is an acronym for 'GNU Not Unix.' If you like the idea that the text the acronym is

based on contains the acronym — a concept known as recursion — you may well be a natural-born programmer. The WinAVR that we use with AVRStudio contains a version of GCC with specific tweeks to make it compile C to AVR assembly language. This is important because our compiler has to provide some not-so-portable methods so that we can use C most efficiently with the AVR memory architecture.

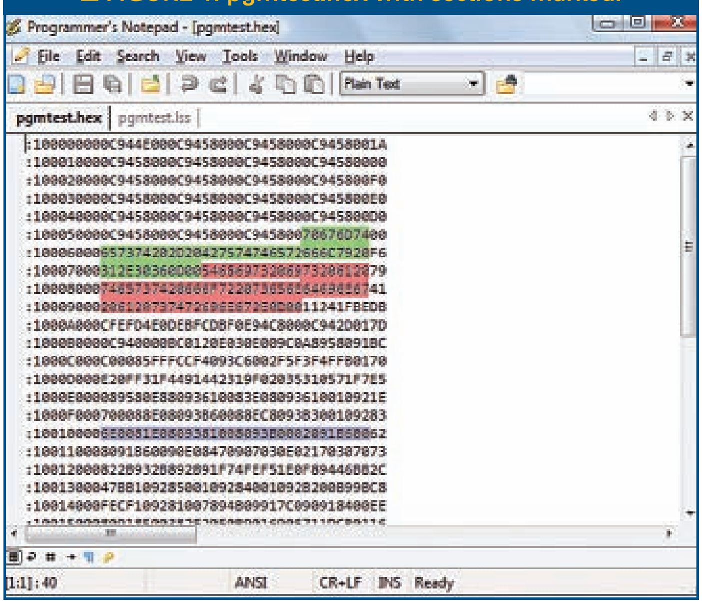
Since regular C isn't aware of our particular memory architecture, we have to use special, non-C concepts for the most efficient use of our memory resources. For instance, we might have a design that uses a serial port and outputs strings to a PC terminal to tell the user what is going on. We might have a switch statement that when it detects someone pressing the big red button, it will call printf() to output the string: "Did you really mean to press the self-destruct button?" [**String** is used in C to describe a sequence of characters that is ended by the null character 0x00.]

Some of us find it very annoying when we give a computer a command and it second-guesses us. If you were a Vista user and you hate the Nanny messages, you might have gotten used to yelling at the terminal something like: 'Of course I meant to press the @%$#*!* button. I pressed it, didn't I?' [Followed by a last thought: "Wait a second, did that say 'self-destruct?'"] We aren't concerned here with destroying ourselves. Instead, we want to know where the AVR is storing the strings it calls in response to button presses. The GCC compiler writes the assembly code to set up memory (including string storage) before the main() function runs, and it copies all variables to SRAM — even constant variables like our string. But wait — isn't a constant variable some sort of oxymoron?

Well, you'd think so but it is really a variable that just happens to not change in this particular program. In another program, the string could be printf ("Did you really mean to press the self-destruct button because you know that it means blowing us both up?"). Either string gets moved from cheap Flash to expensive SRAM and wastes resources — something we don't want to do — so we have to learn special methods to get the compiler to leave the strings in Flash and let us read it from Flash.

Of course, theoretically a compiler could figure out that the string isn't changed in the program and could automatically set things up to read it out of Flash without transferring it to SRAM, however, our free GCC compiler doesn't. (Before we complain, let's remember the price.) We do however, have some methods that will let us keep the strings in Flash, and the avrlibc gives us some special functions that let us handle these strings almost like regular old C does.

■ FIGURE 1. pgmtest.hex with sections marked.



Using AVR Flash To Store And Read Constant Data

In addition to the GCC compiler, our WinAVR toolset provides avrlibc — a library that helps us make better use of C with the AVR. For using Flash, we find a number of useful macros and functions in pgmspace.h.

PROGMEM attribute

I like to have demonstration programs that start off by introducing themselves. For instance, if I'm using the AVR Butterfly with the pgmtest.c source code and this is the sixth version, I might begin the program by sending the string: "pgmtest - Butterfly 1.06\r" to the PC terminal. I could create this string in a HELLO[] array as follows:

```
const char HELLO[] = "pgmtest - Butterfly
1.06\r";
```

If we do this, the GCC compiler will store the string in Flash, but will also cause it to be copied to SRAM when the program starts up. *[Aside: C terminates a string with the '\0' character which is also known as null and has an ASCII value of 0x00 – so that character is the last one in the array.]* With the string in SRAM, the ordinary C string functions such as strcmp() [string compare] from the string.h library can be used with it. Like I mentioned before, though, SRAM is precious so we would like to leave the string in Flash and read it from there. We do this by adding the PROGMEM attribute as follows:

```
const char HELLO[] PROGMEM = "pgmtest -
Butterfly 1.06\r";
```

The compiler will now leave the HELLO[] array in Flash and let us use it from there. The avrlibc provides a special set of string manipulation functions for use with Flash that are similar to those in string.h, but are in pgmspace.h and have a '_P' appended to them. (For example, if we use strcmp_P().) This, of course, means that we aren't using the standard C string library and our code

is less portable. It's a tradeoff well worth the sacrifice, though, if we are using the AVR with the free WinAVR toolset.

PSTR attribute for in line strings

We use PROGMEM to store constant strings and arrays in Flash. We can also use the PSTR attribute to create strings in the parameter list of a function in a line of code. For instance:

```
sendStringP(PSTR("This is a test for sending a
string.\r"));
```

We'll see how this works in our pgmtest.c demonstration program [available in Workshop25.zip at **www.nutsvolts.com**].

Reading sections of Flash program memory

The final demonstration is for reading sections of program memory. Avrlibc has a bunch of functions for accessing program memory, depending on the data type to be accessed, and whether the data is in the lower 64K or in higher memory. We will only look at the function for reading bytes from the lower memory: pgm_read_byte(). We use this function in another function that sends Flash strings out the serial port:

```
void sendStringP(const char *FlashString)
{
        int i = 0;

        // The 'for' logic terminates if the byte
        // is '\0' or if i = 80.
        // '\0' is 'null' and terminates
        // C strings
        // The 80 prevents too much overrun if we
        // get a bad pointer
        // and it limits the string size
        for( i = 0 ; pgm_read_byte(&Flash
        String[i]) && i < 80; i++)
        {
                sendByte(pgm_read_byte
                (&FlashString[i]));
        }
}
```

Now, please relax when reading this ... yes, there will be pointers. The first is the pointer FlashString which is set to point to a constant character; in our case, the first element of a string array. We then use it as an array with the subscript 'i' being incremented to indicate the specific character in the FlashString array; we add the '&' 'address of' operator to get the specific address of the specific character at that position in the array. See ... that wasn't so hard, was it?

But then we do something a bit doofy in the 'for' loop that runs the loop until one of two things happen as shown below:

```
pgm_read_byte(&FlashString[i]) && i < 80;
```

We want the loop to exit if one of two conditions occur. The loop will run as long as &FlashString[i] is true — meaning it is not equal to 0 and 'i' is less than 80. We do this because we terminate a string with 0x00 (the null character), so we want to end our loop if we see that character. We will also end the loop if 'i' gets up to 80, thus limiting our string size to 80 characters. This assures that the for loop will exit if we accidentally send it a pointer to an array that isn't terminated by 0x00.

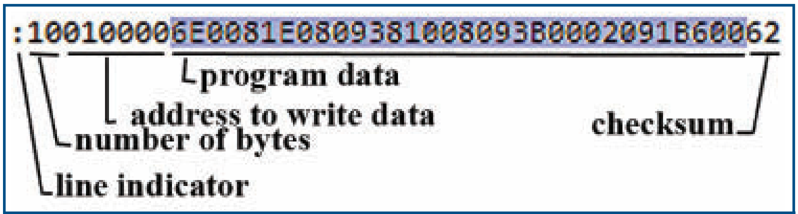


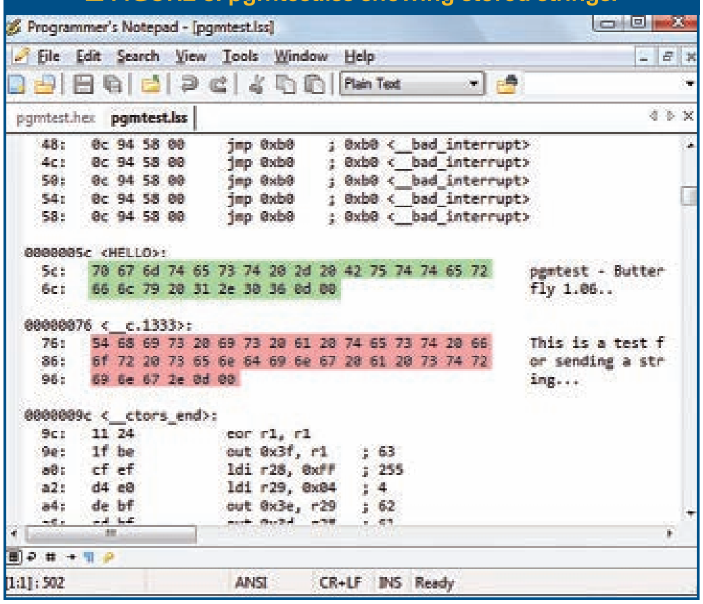
FIGURE 2. Intel hex format for pgmtest.hex data.

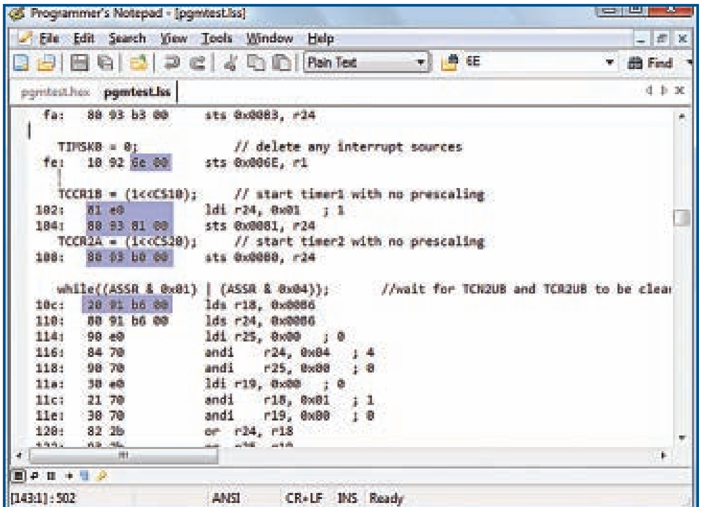
Let's Look At The Flash Memory

When we compile our pgmtest.c program (we'll do that later), the compiler generates several files. The pgmtest.hex file is the file we upload to our development board using the bootloader resident on the AVR. The pgmtest.hex file (in the source code default directory) contains the binary code for program in the form of an Intel hex file (shown in **Figure 1**). [Note that I've marked several lines in color because we will look at these later]. You can use Programmer's Notepad [a great tool you can find in your WinAVR directory] to open the hex file.

Figure 2 shows how our data is formatted. Each line in the file begins with ':' then '10' to indicate that 0x10 (16 decimal) bytes of code are in the line. This is followed by two hex bytes that give the address that the code should be written to, followed by the 16 bytes to be

FIGURE 3. pgmtest.lss showing stored strings.



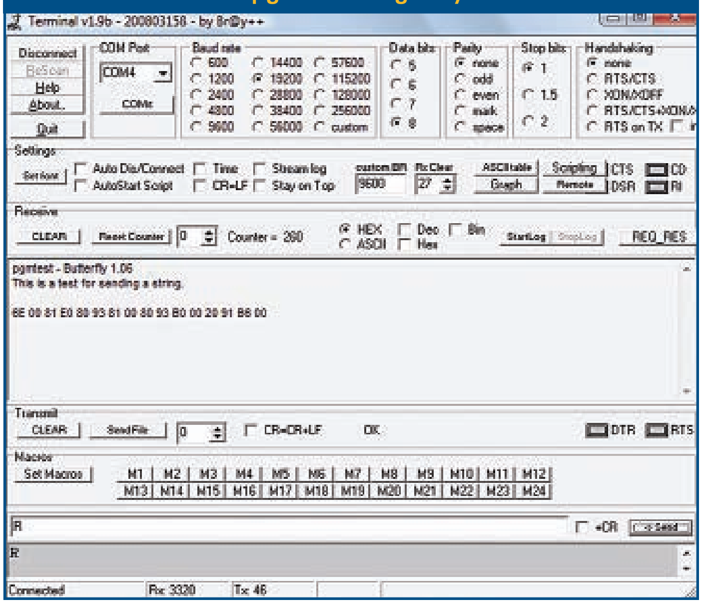


■ FIGURE 4. pgmtest.lss showing 16 bytes stored at address 0x0100.

written. The last byte in the line is a checksum. As you can see from **Figure 1**, I've marked three sections of the hex file. The green is for the data for the string: "pgmtest - Butterfly 1.06\r". The pink is for "This is a test for sending a string.\r".And the blue is 16 bytes beginning at memory location 0x0100 that we will read in the demonstration program.

In **Figures 3** and **4** we look at the pgmtest.lss file that is also in the default directory along with pgmtest.hex. **Figure 3** shows the green data that is stored beginning at address 0x005C, and the red data stored beginning at address 0x0076. You can see that the .lss file also shows the characters for the data to the right. In **Figure 4** we see the 16 bytes of code that are stored beginning at address 0x0100 and to the right we see the assembly instructions that this code represents. Above the code we see the C instructions. The .lss can be very useful for debugging and

■ FIGURE 5. pgmtest using Bray's Terminal.



for learning how the compiler translates our C code into the AVR assembly language.

The pgmtest.c demonstration program will print the two strings stored in Flash and when you send it 'R' it will read out the 16 bytes of Flash beginning at address 0x0100.

Program Memory Demonstration — pgmtest.c

The full source code for this demonstration is included in Workshop25.zip on the *NV* site **www.nutsvolts.com**. In this section, we will look at a few of the more relevant items.

One source file for multiple devices

The following discussion isn't related to memory, but to creating the demonstration program pgmtest.c. At one time, I found that lots of #define and #ifdef in source code seemed to make things more confusing. It does, but it also makes it possible to write one source code file that can be compiled for multiple devices. This comes in handy when you have situations like the one that requires different register names for the USART in different AVRs (as is the case of the Butterfly's ATmega169 versus the BeAVR40's ATmega644). The compiler preprocessor looks for #if defined structures and, based on what was previously defined, it selects the correct code section. For instance, in pgmtest.c you see:

```
#define Butterfly // ATmega169
//#define Arduino // ATmega328
//#define BeAVR40 // ATmega644

// SmileyUSART.h uses the above defines
// Note that Butterfly USART runs at 19200 Baud
// while the Arduino and BeAVR40 run at
// 57600 Baud
#include "SmileyUSART.h"

#if defined(Arduino)
const char HELLO[] PROGMEM = "pgmtest -
Arduino 1.01\r ";
#elif defined (Butterfly)
const char HELLO[] PROGMEM = "pgmtest -
Butterfly 1.04\r ";
#elif defined (BeAVR40)
const char HELLO[] PROGMEM = "pgmtest -
BeAVR40 1.00\r";
#else
const char HELLO[] PROGMEM = "pgmtest -
UNDEFINED\r";
#endif
```

There are three main things going on here. First, we select the platform we want to compile our code for: either the Butterfly, the Arduino, or the BeAVR40. We remove the preprocessor comment delimiter \\ in front of the one we want to compile the code for. Note that we must also leave the \\ in front of the other two or we'll get some strange errors. The second thing to note is that the include file SmileyUSART.h follows this define list. That is because the SmileyUSART header file needs to know

which device is selected; the preprocessor writes the whole header file at this point in the code before it compiles it. *[Aside: Note that the Butterfly baud is 19200 while the Arduino and BeAVR40 baud is 57600]*. The third thing to note is that there are four HELLO[] character arrays, but only the one with the device defined for it is used by the preprocessor. The fourth is included in case none of the legitimate possibilities are defined.

Using The pgmtest.c Demonstration Program

Download the pgmtest.hex to your device using the methods learned in the earlier Smiley's Workshop(s) for that device. Notice that in **Figure 5** the first two lines in the Receive window are in plain text, while the third line is a list of hexadecimal characters. To get Bray's to show the data this way, you have to set the Receive window checkbox to ASCII when the pgmtest first opens; then you set it to HEX before you send the 'R' from the send window. This will show you the two strings and the line of hex code discussed above.

This month, we looked at AVR memory principles and applied those principles to software that can run on one of three development platforms: the AVR Butterfly, the Arduino, and the BeAVR40. If you want to learn more using the Butterfly or the Arduino, you can get a book and projects kit from the *Nuts & Volts* shop. Next month, we will apply what we've learned about AVR memory to begin learning how to write our own bootloader. **NV**

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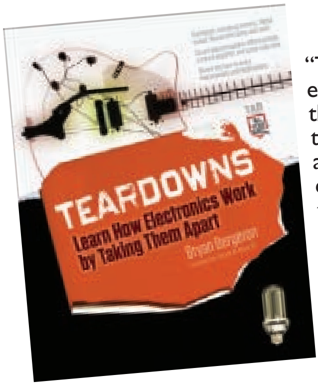

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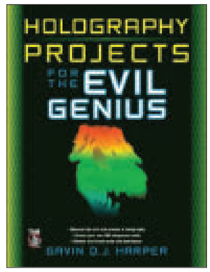

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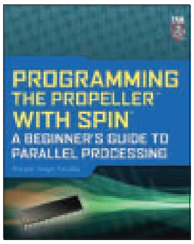

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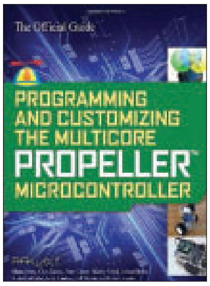

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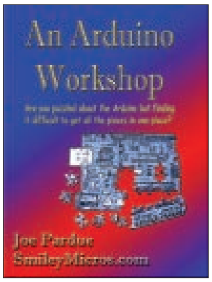

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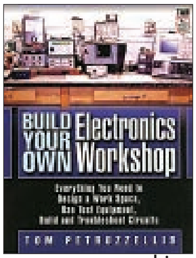

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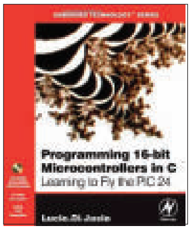

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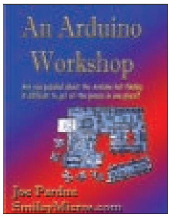

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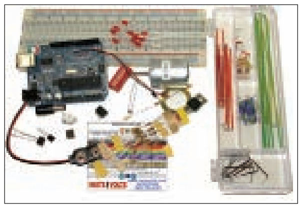

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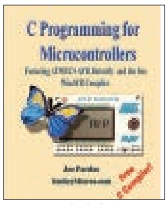

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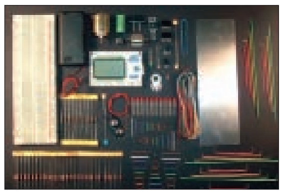

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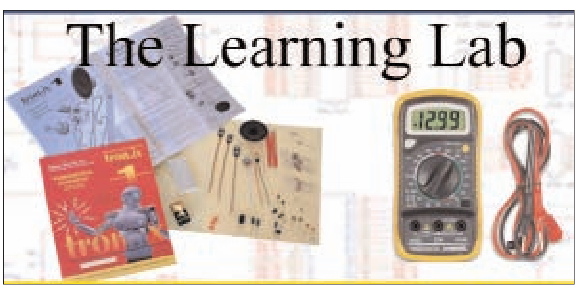

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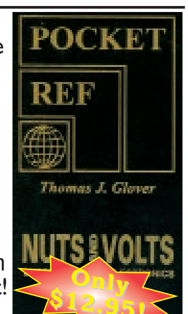

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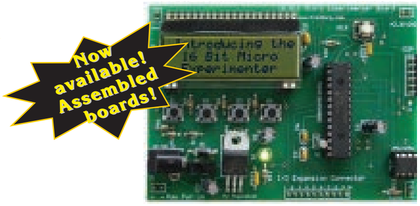

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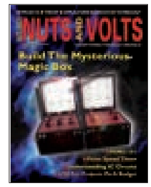

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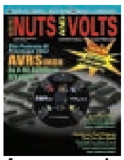

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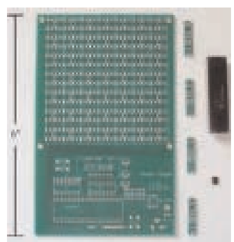

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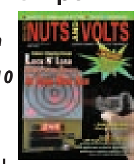

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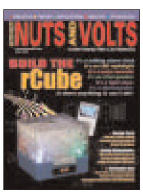

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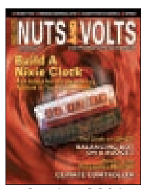

October 2006

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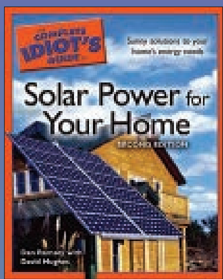

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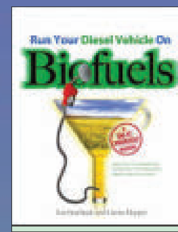

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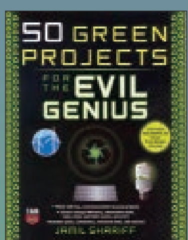

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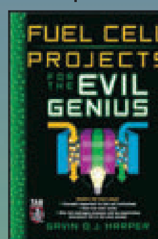

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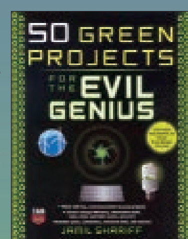

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The Whirlybird Three-Phase Wind Turbine Kit is one of the great projects from the series of articles by John Gavlik, "Experimenting with Alternative Energy." In Parts 6 and 7, he teaches you how to produce the most electricity utilizing the wind. For kit details, please visit our webstore.

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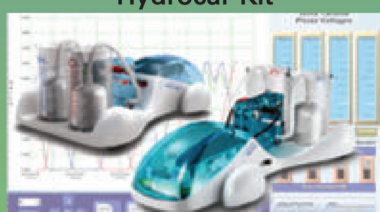
Hydrocar Kit



The Hydrocar is used in a couple of great projects from the series of articles by John Gavlik, "Experimenting with Alternative Energy." In Parts 10 and 11, he teaches you the operation of the Polymer Electrolyte Membrane "reversible" fuel cell. For kit details and a demo video, please visit our webstore.

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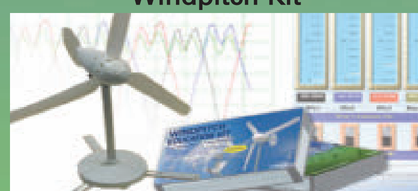

The WindPitch Wind Turbine Kit is a miniature real-working wind turbine and is one of the great projects from the series of articles by John Gavlik, "Experimenting with Alternative Energy." In Parts 8 and 9, he teaches you how to produce the most power by evaluating the pitch (setting angle) of the profiled blades. For kit details, please visit our webstore.

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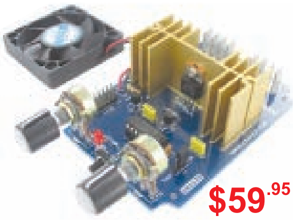

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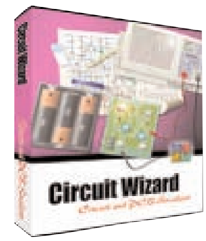

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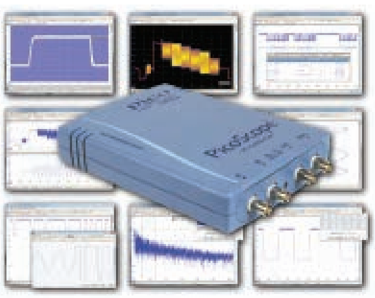

The new PicoScope 4226 and 4227 represent the sixth generation of high-resolution oscilloscopes from Pico Technology. Powered from the USB port and including a built-in arbitrary waveform generator, these scopes contain everything you need to make accurate high-speed measurements. Just plug one into a laptop or desktop computer, run the software supplied, and get to work.

The latest PicoScope 4000 Series oscilloscopes have two 12-bit input channels with a bandwidth of 50 MHz or 100 MHz, allowing them to capture detailed waveforms for production testing, scientific analysis, and electronic design and debugging. The third input is a dedicated external trigger. The fourth connector is the output of the signal generator which allows you to load an arbitrary test signal, draw your own waveform using the graphical editor, or use one of the six preset waveforms.

The PicoScope 4227 can sample at rates up to 250 MS/s, and the PicoScope 4226 up to 125 MS/s. Both models have a deep 32 megasample buffer memory that

continued from page 26

enables the maximum sampling rate to be used even on slow timebases. The buffer can hold up to 10,000 waveforms which are displayed in a pop-up navigator window for easy access.

A fully enabled version of the PicoScope oscilloscope software is included in the price. PicoScope for Windows offers a wide range of advanced functions such as mask limit testing, alarms, serial data decoding, programmable low-pass filtering, math channels, reference waveforms, Digital Color and Analog Persistence display modes, and XY mode. The advanced trigger types include pulse width, window, interval, dropout, and runt pulse.

The units include probes and a carrying case. Along with all of the features listed above, unlimited free software updates are available from their website, along with free technical support. There is a free five-year parts and labor warranty against manufacturing faults.

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The 5491B offers an accuracy of 0.02%, a digital dual display for viewing two measurements simultaneously, a fast measurement rate of up to 25 readings per second, threshold settings for quick Pass/Fail testing, plus the ability to download measurement values to a computer via USB or RS-232 interfaces using the SCPI protocol.

The unit's AC+DC capability captures any DC effects within the measured voltage or current for the most accurate results. Housed in a rugged case for easy stacking, the front panel of the 5491B has a bright display and tactile pushbutton control with easy-to-follow second function commands.

This workhorse instrument provides all expected measurements of AC and DC voltage to 750V and 1,000V, respectively, AC and DC current to 20A, resistance, frequency, and continuity test. There are also built-in math functions of REL (relative) for offset measuring, Max/Min for capturing highest and lowest values, dB, dBm, Data Hold, and Compare.

For more information, contact:
B&K Precision
Web: **www.bkprecision.com**

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>>> QUESTIONS

Heating Element Control Circuit

I'm looking for a control circuit (120 AC) for an electric smoker heating element that doesn't have the wide temperature swings a normal thermostat controller has. It would need to be rated to at least 15 amps. For example, using a 210-220F range:

1. Below 210F — Heating element is at full power.

2. Between 210-220F — Power ramps down as the temperature nears 220F.

3. Above 220F — Heating element is off or at the lowest power setting.

#8101 **Curt Timmerman**
Big Lake, AK

ADC To Control Motor Speed

How does the ADC circuit control the speed of a motor?

I know that it samples the EMF from the motor and feeds it back via a comparator. If it is going too fast, how do you slow it down? I just built a motor control module that can control or feed back the EMF from 001 to 255. I would expect that it goes through a DAC circuit and feed back to the motor. But how? The motor circuit has two connections:

a) PortB bit 0: Turns on the motor.

b) PortA bit 1: Feedback circuit that samples the EMF voltage.

When I press 010, it slows it down; when I press 000, it slows it down more but it is still running — why?

#8102 **Frank Gutierrez**
Clovis, CA

Automotive Black Box

I'm trying to design an automotive black box that will record four cameras facing the front, rear, and each side in a 'ring buffer' fashion onto Flash memory. The buffer would not need to be very large; five minutes would work. When a button is pushed or some other external trigger occurs, the box would save the four recording buffers into individual files and keep recording.

I thought about using MP4 DVR units or digital cameras with video record capability, but each has their own shortcomings. Any ideas?

#8103 **John Duncan**
Indianapolis, IN

MSN Direct

My coffee maker works off the MSN Direct signal. Two more years and MS turns it off. Is there a way to build the FM generator with the time in the signal so my coffee maker can at least wake me up with coffee already brewed?

#8104 **Jimmy Rogers**
Jacksonville Beach, FL

>>> ANSWERS

[#3102 - March 2010]

Convert Old Record Player To Record To USB

I have a stack of records from the '50s, '60s, and '70s, and two record players. I saw a device in a store that would record your records to USB. Can't I build my own? Any suggestions?

#1 This depends on how much you value your time and how much of an audiophile you are. Remember that software may be needed to remove pops and create tracks, as well. For approximately $30, you can buy a device, software, and an RIAA preamp. Is it worth it? See **www.zzounds.com/item--BEHUFO202**. If you value your audio, an RIAA preamp can cost you big bucks such as the one found at **www.audiophileproducts.com/korora**. It includes moving magnet and moving coil modes and various loading values; 78 RPM records need many different equalization techniques.

Here is something a bit easier on the wallet: **www.ramseyelectronics.com/cgi-bin/commerce.exe?preadd=action&key=US100**.

If you're really interested in building a product from scratch, see **www.semiconductorstore.com/cart/pc/viewPrd.asp?idproduct=42808**. Here is what you asked for, a kit: **www.hagtech.com/pdf/ripper.pdf**. There are a lot of choices.

Ron Dozier
Wilmington, DE

#2 In order to transcribe phonograph disks to digital computer files, you will need two devices: an analog-signal stereo preamplifer with an RIAA transfer characteristic and a stereo analog-to-USB converter. The project ought not to cost you a mint.

A review of seven inexpensive preamplifiers — priced from $13.50 to $77.99 — can be found at **www.audioxpress.com/reviews/media/403hansen2090.pdf**. The reviewers did not seem to find a linear relationship between price and quality. The RIAA preamplifier transfer characteristic is needed to compensate for the nonlinear output-voltage-with-frequency characteristic of the magnetic phonograph transducer.

The stereo analog-to-USB converter function can be provided by an EasyCap model SINOSV3529 which can be had for about $15. It will not only convert stereo audio signals but it can also convert analog video signals having a composite video input and an S-video input with NTSC or PAL format compatibility.

Peter Goodwin
Rockport, MA

Send all questions and answers by email to **forum@nutsvolts.com**
*Check at **www.nutsvolts.com** for tips and info on submitting to the forum.*

[#3103 - March 2010]
AC Alternator

I have been experimenting with a 10,000 watt AC alternator that outputs 110/220 VAC for use as a backup power source.

I am using the variable speed from the gas engine that turns the alternator to create a variable AC voltage output. An alternator of this type has no permanent magnet so it needs to get up to some RPM before it generates ANY voltage at all. On mine, this kicks in somewhere between 35 and 50 VAC.

How does this type of alternator actually work? Is it possible to excite the fields externally so the output voltage kicks in consistently at low RPM?

The alternating current synchronous generator is a fairly simple machine; as you know, some laws apply. The theory and math are readily found online. My assumption is that your generator is a two pole revolving-field direct drive unit turning at 3,600 RPM originally. The current for the field may be supplied through slip-rings and brushes, or the generator may be brushless with the field current supplied by secondary windings or other means. This is typical. The term synchronous describes the fact that 3,600 RPM at the input (gas engine, turbine, etc.) of your generator will give the rated output voltage/current at 60 Hz. This again is determined by the number of poles on the field and on the stator. The mechanism that makes the 60 Hz stay at 60 Hz is the governor on your engine; it makes sure the engine runs at a fixed 3,600 RPM regardless of load. The voltage regulator on the generator is designed to keep the output voltage stable at this rated input RPM, regardless of changes in load current.

Now to get it all started, how is this done with no external source of current or permanent magnets? Some residual magnetism is in the iron and steel that makes up the core of the field and the lamination where the stator is wound. This is where the exciter does its job. As the generator starts to reach its rated speed, some current will be produced in either the field or seperate exciter windings. This current will build up and be fed back to the field winding either by rectification or an autotransformer. Magnetism in the field will rapidly build up — as will the generator output voltage — until the voltage regulator limits the field current to keep the output at the rated voltage. All is accomplished without the need for an external field current supply, but when you slow the generator below the designed speed the abovementioned system will reach a point where it can no longer self-sustain field current and drop out.

If the generator is of the brushless variety, trying to control field current independently of the existing regulator/exciter may be a challenge. You will have to determine how the field is powered and controlled; this could get quite complex. Google the make and you may find the wiring diagram; that's always a good start.

If the generator has slip-rings and brushes to supply the rotating field, it is a simple matter of connecting your own source of field current. A fairly low voltage and current should do; use a variable resistance to control the current. This will allow the generator to produce voltage at lower speeds than the existing exciter circuit. Bear in mind that opening the field circuit with the generator running can produce a large arc as the field collapses. Safety first.

Carl Berg
via email

[#3107 - March 2010]
Anemometer Circuit

I'm looking for an anemometer circuit using the cooling effect on transistors. A circuit with an analog output I can interface to a microcontroller would be great as I plan to add other sensors. Mechanical anemometers need to be calibrated which I'd like to avoid (and I'd rather build a circuit anyway).

It should measure "normal" wind speeds (up to maybe 50 mph).

There is a circuit in the Linear Technology Corp LT1013/LT1014 op-amp datasheet for a hot wire anemometer. It uses a small incandescent lamp with the glass envelope removed as the hot wire. The link **http://cds.linear.com/docs/datasheet/10134fc.pdf** goes to the LT1013/LT1014 datasheet. The anemometer circuit is on page 11 under "Typical Applications."

Searching for or going to the datasheet for "LT1013" produces a different datasheet for LT1013 alone and it does not have the anemometer circuit on it. A search for "hot wire anemometers" also yields a lot of information and some circuits.

Charlie Raths
Mayville, MI

[#4101 - April 2010]
Using PIC Processor to Generate DTMF

I am looking for info to use PICs to generate DTMF. I am using a PIC 18F2431. Any assembly code would be of great help.

#1 The Scenix SX28 (now from Ubicom) is quite similar to many of the PIC family processors. There are some excellent ap-notes for a DTMF tone generator — including theory of operation and fully commented source code — on their site.

This requires minimal hardware and you should be able to adapt the source code. Here are some current links:

www.sxlist.com/techref/ubicom/virtperf.htm = Virtualperipherals
www.sxlist.com/images/sxlist/AN6_DTMF_gen.PDF = Theory of Operation
www.sxlist.com/images/sxlist/dtmf_gen_1_3_4.SRC = Source code

If your PIC doesn't support a high clock rate, you should still be able to use this by adjusting the loop counts to scale to your clock rate.

Barry Cole
Camas, WA

#2 Check out application note AN543 on the Microchip website. It explains general-purpose tone generation and offers assembler source for the PIC17C42 which I'm sure you can get to run on your 18F part.

Dan Danknick
Santa Ana, CA

[#4102 - April 2010]
Car Autoranging Ammeter

Need a circuit for an autoranging car ammeter. In-line cable shunt output at the battery. Resistor short protection at the battery for a pair of sense wires running to the circuit and meter under the dash. Car battery powered, no microprocessors, low range 0 to 10 amps, high engine start range for starting current, d'Arsonval meter, not digital.

Want to see relatively fast amperage changes. Should this go in the negative or positive side of the battery? Accuracy on 0-10 amp range say 10% or better; 20% or better on the engine start range. KISS.

The simplest solution would be to use two shunts, two sets of short-circuit protectors, and two d'Arsonval meters. The two shunts would be rated something on the order of 20 amperes and 200 amperes full scale, or as appropriate. I'd use 50 mV shunts (rather than 100 mV shunts) because the alternator output voltage will be regulated with reference to the load side of the low current shunt and this introduces only a 0.4% error in actual battery charging voltage. Both meters would be rated 50 mV full scale, but the low current meter would need to be a zero-center instrument (-50 mV to +50 mV).

However, one instrument with the ability to switch between two current ranges was requested. I believe that the scheme illustrated in **Figure 1** addresses that challenge. The battery, ignition switch, starter, and starter relay are considered to be pre-existing equipment in the car. A negative-ground system is shown.

The two shunts are as above, delivering 50 mV for full-scale ratings of 20 amperes and 200 amperes, or as appropriate. They are located at or very close to the positive post of the battery. The low current shunt is inserted into the existing lead that connects to all of the non-starter loads in the car, plus the alternator. The high current shunt is inserted into the non-grounded starter cable.

Fuses F1-F4 are 1/4" diameter 0.1 ampere rapid-acting devices (type AGC or GBB) contained within in-line weatherproof fuseholders. Resistors were specified, but resistors affect the voltage delivered to the indicating instrument, and with only 50 mV to play with full scale, any loss is significant. Fuses are better.

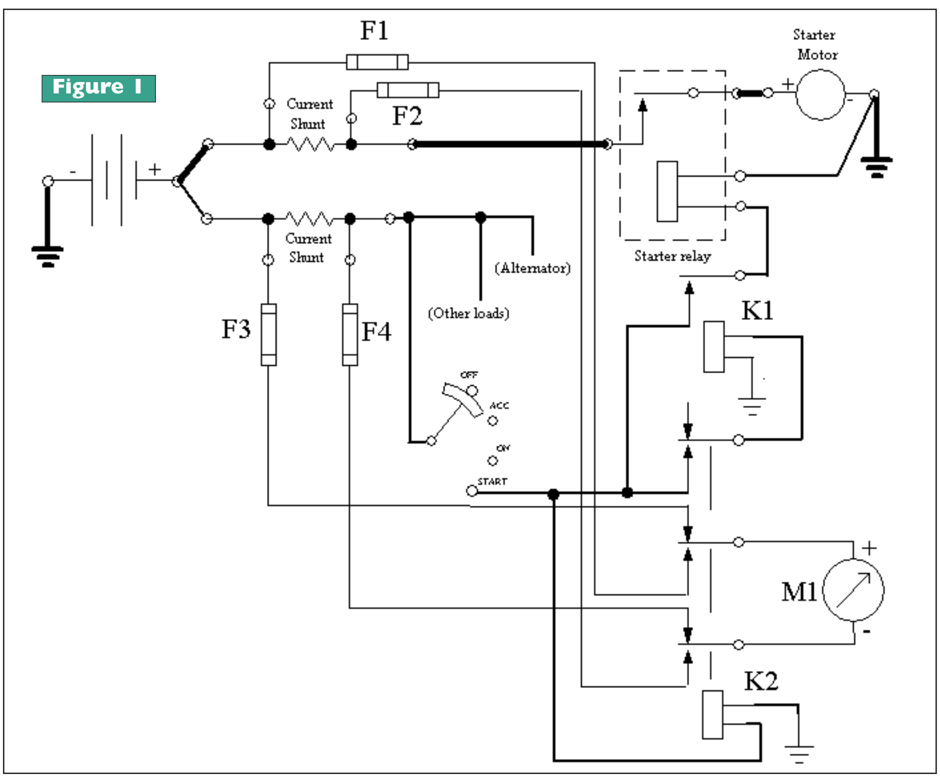

Figure 1

M1 is a 50 mV (full-scale) zero-center instrument of appropriate size and accuracy with its scale hand-calibrated to match the shunts.

K2 is a fast-acting three-pole double-throw insrument relay having gold contacts and a 12 volt DC coil. Gold crossbar contacts would be the best. We're switching millivolt signals and voltage barriers due to dry-contact phenomena cannot be tolerated.

K1 is a sensitive single-pole relay (one normally-open contact is required) having a low current 12 volt DC coil. It exists because the contacts in K2 are small and the starter relay is an unknown device, so K1 exists to switch the load presented by the starter relay. It also adds delay which favors the circuit.

In operation, K2 is normally not energized hence M1 is connected across the low current shunt. When the car engine is to be started, the operator rotates the ignition switch to the START position which energizes relay K2. The uppermost set of contacts on K2 close and energize relay K1; and through K1, the starter relay; and through the starter relay, the starter motor.

But at the same time that K2 causes K1 to be energized, its remaining two sets of contacts have likewise transferred such that meter M1 is now connected across the high current shunt, hence M1 will monitor the starter motor current once it is energized.

When the engine begins to run, the operator releases the ignition switch key, breaking the connection to the START contact.

Since the START contact carries the full load of the starter relay coil — and also the coils of K1 and K2 — the starter motor will be disconnected rapidly and before the contacts on K2 transfer back to their de-energized position, and thus M1 can be connected safely to the low current shunt.

Peter A. Goodwin
Rockport, MA

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www.circuitspecialists.com/PM-128E-BACKLIT

3-1/2 Digit Digital LCD Panel Meter
PM-138
1+ $10.90ea | 10+ $7.85ea | 25+ $6.85ea | 100+ $6.45ea | 250+ $5.90ea
www.circuitspecialists.com/PM-138

3-1/2 Digit Digital LCD Panel Meter
PM-188BL
1+ $12.50ea | 10+ $8.90ea | 25+ $7.90ea | 100+ $7.45ea | 250+ $6.70ea
www.circuitspecialists.com/PM-188BL

3-1/2 Digit Digital LCD Panel Meter
PM-228
1+ $12.50ea | 10+ $8.90ea | 25+ $7.90ea | 100+ $7.45ea | 250+ $6.70ea
www.circuitspecialists.com/PM-228

3-1/2 Digit Digital LCD Panel Meter
PM-328
1+ $19.88ea | 10+ $16.40ea | 25+ $14.90ea | 100+ $13.66ea | 250+ $11.93ea
www.circuitspecialists.com/PM-328

3-1/2 Digit Digital LCD Panel Meter
PM-438
1+ $10.95ea | 10+ $7.90ea | 25+ $6.90ea | 100+ $6.50ea | 250+ $5.95ea
www.circuitspecialists.com/PM-438

3-1/2 LCD 5V Common Ground Panel Meter
PM-1028A
1+ $13.95ea | 10+ $11.84ea | 100+ $8.89ea | 250+ $7.15ea
www.circuitspecialists.com/PM-1028A

3-1/2 Backlit LCD 5V Com Ground Panel Meter
PM-1028B
1+ $15.95ea | 10+ $13.89ea | 100+ $10.49ea | 250+ $9.65ea
www.circuitspecialists.com/PM-1028B

3-1/2 LCD Backlit 5V Com Ground Panel Meter
PM-1028B-BACKLIT
1+ $13.95ea | 10+ $11.84ea | 100+ $8.89ea | 250+ $7.15ea
www.circuitspecialists.com/PM-1028B-BACKLIT

9V Miniature LCD Digital Panel Meter
CX101A
1+ $13.50ea | 10+ $10.90ea | 25+ $9.80ea | 100+ $8.95ea | 250+ $7.90ea
www.circuitspecialists.com/PM-1028B

5V Miniature LCD Digital Panel Meter
CX101B
1+ $13.50ea | 10+ $10.90ea | 25+ $9.80ea | 100+ $8.95ea | 250+ $7.90ea
www.circuitspecialists.com/CX101B

5V Miniature LCD Digital Panel Meter
CX101BG
1+ $13.50ea | 10+ $10.90ea | 25+ $9.80ea | 100+ $8.95ea | 250+ $7.90ea
www.circuitspecialists.com/CX101BG

LED 9V Independent Ground Panel Meter
PM-129A
1+ $13.49ea | 10+ $9.85ea | 25+ $8.95ea | 100+ $9.80ea | 250+ $7.29ea
www.circuitspecialists.com/PM-129A

LED 5V Common Ground Panel Meter
PM-129B
1+ $12.95ea | 10+ $10.49ea | 25+ $9.55ea | 100+ $8.35ea | 250+ $7.89ea
www.circuitspecialists.com/PM-1028B

3LED 9V Independent Ground Panel Meter
PM-1029A
1+ $14.95ea | 10+ $12.50ea | 100+ 9.95ea | 250+ $7.89ea
www.circuitspecialists.com/PM-1029A

LED 5V Common Ground Panel Meter
PM-1029B
1+ $15.95ea | 10+ $13.40ea | 100+ $10.79ea | 250+ $8.65ea
www.circuitspecialists.com/PM-1029B

3-1/2 Digit LED Digital Panel Meter
CX102A
1+ $11.49ea | 10+ $9.54ea | 25+ $8.67ea | 100+ $7.95ea | 250+ $6.95ea
www.circuitspecialists.com/CX102A

3-1/2 Digit LED 5V Common Ground Panel Meter
CX102B
1+ $14.95ea | 10+ $10.49ea | 25+ $9.58ea | 100+ $8.59ea | 250+ $7.59ea
www.circuitspecialists.com/CX102B

Check out out complete selection at www.circuitspecialists.com/Panel_Meters

Aardvark II

Dual Camera

Wireless Inspection Camera

With Color 3.5" LCD Recordable Monitor

Your Extended Eyes & Hands!

Ideal for Law Enforcement, Post Fire Inspection, Plumbing, Facilities Maintenence, Security Companies, & Many Other Uses!

See It!
Clearly in narrow spots, even in total darkness or underwater.

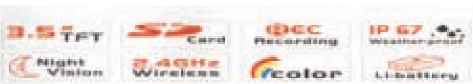
Find It!
Fast. No more struggling with a mirror & flash light.

Solve It!
Easily, speed up the solution with extended accessories.

Record It!
With the 3.5" LCD recordable monitor, you can capture pictures or record video for documentation.

Full specifications at www.CircuitSpecialists.com/Aardvark

The Aardvark Wireless Inspection Camera is the only dual camera video borescope on the market today. With both a 17mm camera head that includes three atachable accessories and a 9mm camera head for tighter locations. Both cameras are mounted on 3ft flexible shafts. The flexible shaft makes the Aardvark great for inspecting hard to reach or confined areas like sink drains, AC Vents, engine compartments or anywhere space is limited. The Aardvark II comes with with a 3.5 inch color LCD monitor. The monitor is wireless and may be separated from the main unit for ease of operation. Still pictures or video can also be recorded and stored on a 2GB MicroSD card (included). The Aardvark's monitor also has connections for composite video output for a larger monitor/recorder and USB interface for computer connection. Also included is an AC adapter/charger, video cable and USB cable. Optional 3 ft flexible extensions are available to extend the Aardvark's reach (Up to 5 may be added for a total reach of 18 feet!).



Item # **AARDVARK** **$249.00**

3ft Extension **AARDVARK-EXT $24.95**

USB Digital Storage Oscilloscopes

* High performance:
* USB connected: Uses USB and supports plug'n play, with 12Mbp communication speed.
* Best performance for your dollar: Thease units have many features that are comparable to the high speedah stand-alone DSOs. But costs a fraction of the price.
* No external power required: Bus-powered from the host computers USB port.
* Probes & USB cable included.
* Easy to use: Intuitive and easy to understand.
* Various data formats: Can save wavrfrom in the following formats: .txt .jpg .bmp & MS excel/word

40MHz **DSO-2090** **$169.00**
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60MHz **DSO-2150** **$194.00**
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100HMz **DSO-2250** **$249.00**
www.circuitspecialists.com/DSO-2250

200MHz **DSO-5200** **$289.00**
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200MHz **DSO-5200A** **$355.00**
www.circuitspecialists.com/DSO-5200A

Specifications	DSO-2090	DSO-2150	DSO-2250	DSO-5200 /5200A
Channels	2 Channels			
Impedence	1M 25pF			
Coupling	AC/DC/GND			
Vertical resolution	8 Bit			9 Bit
Gain Range	10mV-5V, 9 Steps			10mV-10V, 10Steps
DC Accuracy	+/- 3%			
Timebase Range	4ns - 1h 38 Steps			2ns-1h, 39 Steps
Vertical adjustable	Yes			
Input protection	Diode clamping			
X-Y	Yes			
Autoset	30Hz~40MHz	30Hz~60MHz	30Hz~100MHz	30Hz~200MHz
EXT. input	Yes			
Trigger Mode	Auto / Normal / Single			
Trigger Slope	+/-			
Trigger Level Adj.	Yes			
Trigger Type	Rising edge / Falling Edge			
Trigger Source	Ch1 / Ch2 / EXT			
Pre/Post trigger	0-100%			
Buffer size	10K-32K per ch			10K-512KB per ch
Shot Bandwidth	DC to 40MHz	DC to 60MHz	DC to 100MHz	100MHz
Max Sanple Rate	100MS/s	150MS/s	250MS/s	200MS/s / 250MS/s
Sampling Selection	Yes			
Waveform Display	port/line, waveform average, persistence, intensity			
Network	open / close			
Vertical Mode	Ch1, Ch2, Dual, Add			
CursorMeasurement	Yes			
Spectrum Analyzer				
Channels	2 Channels			
Math	FFT, addition, subtraction, multiplication, division.			
Bandwidth	40 MHz	60 MHz	100MHz	200 MHz
Cursor	Frequency, Voltage			
Data Samples	10K-32K/Ch			10K-1M/Ch

gas Sensors

Gas Sensors are used in gas detection equipment for detecting specific gases in home, automotive or industrial settings. This line of sensors can be interfaced with any Parallax microcontroller, and would be a good addition to any projects needing to sense the presence of the following gases:

CO (Carbon Monoxide)
- Sensor - #605-00007; $4.99
- Module - #27931; $29.99

CO_2 (Carbon Dioxide)
- Sensor - #605-00010; $19.99
- Module - #27929; $35.99

CH_4 (Methane)
- Sensor - #605-00008; $4.99
- Module - #27930; $29.99

LPG (Propane)
- Sensor - #605-00009; $4.99
- Module - #27932; $29.99

C_2H_5OH (Alcohol/Benzine)
- Sensor - #605-00011; $4.99

Order 4 modules and save over 20%! The **Gas Sensor Sampler Kit** (#27901; $99.99) includes one each of the CO, CO_2, CH_4, and LPG modules.

Shop Parallax **Gas Sensors** online at www.parallax.com or call Sales toll-free: 888-512-1024 (M-F, 7am-5pm, PDT).

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